A Reference Handbook

of

THE MEDICAL SCIENCES

EMBRACING THE ENTIRE RANGE OF

SCIENTIFIC AND PRACTICAL MEDICINE

AND

ALLIED SCIENCE

BY VARIOUS WRITERS

A NEW EDITION, COMPLETELY REVISED AND REWRITTEN

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A REFERENCE HANDBOOK

OF

THE MEDICAL SCIENCES.

Inflammation.

INFLAMMATION.—Under the term inflammation may be understood the changes which take place in a tissue on the receipt of an injury, including not only those immediately produced by the injurious agent acting directly on the tissues but also the more remote changes. Such a definition strictly carried out would include the special pathology of organs, because in every organ the process may be modified by variations in structure and function. It would include the study of all injurious agents, and among them the bacteria and the changes which these severally may produce. Even malformations would not be excluded because most of these are due to injurious conditions or agents, acting on the embryo and influencing or preventing development. Tumors might possibly not come within the meaning of the word, though even here there is a possibility that the growths may be referred in part to the action of injurious agents acting on the tissues of the embryo or the adult. In fact all pathology is but a study of injurious agents or conditions and their effects. There are so many conditions produced by injury and some of them are so complicated that it has been proposed to exclude any word descriptive of the whole and to consider the different conditions separately. In this article I shall attempt to give a general description of the most common conditions which are produced by injury. These conditions are so modified by the character of the injurious agent, the structure of the tissue it acts upon, and the greater or less resistance of the individual, that a general description certainly cannot fit all cases, and it may not be true in its entirety in even a single instance. With the extension of our knowledge of pathological processes, or rather with the substitution of knowledge for conjecture, the difficulty of general description increases. Even in the experimental study of injuries, when all the conditions can be controlled to a great extent, it is difficult to produce exactly the same lesion, in the same tissues, under apparently the same conditions.

When a tissue is placed under the action of abnormal conditions it undergoes injury and probably in all cases structural alterations are produced in it. In some cases these structural alterations are easily recognized and come under the head of the various degenerations. In other cases we must assume the alteration from the change in function which follows. There is a very different degree of vulnerability in the different tissues of the body, and some may be destroyed by causes which produce no effect upon others.

It is very rare that single elements in a tissue are alone affected by the injurious agent, though in a complex tissue the different elements may have different degrees of vulnerability, and the injurious effects are then more marked in some elements than in others. We usually find changes in all the constituents of a tissue, some of which may be due to the action of the primary cause, while others are secondary and due to the changes which the acting cause has produced. Any injury to a tissue must influence its nutrition, and so intimate is the association between the circulation and the nutrition of a part that any influence affecting the nutrition will produce changes in the character of the circulation. The vessels in a tissue may be immediately influenced by the primary action of the injurious agent, but the influence of this agent extends far beyond this. In non-vascular tissues which are nourished solely by lymphatic channels, the vessels from which the nourishing lymph passages are supplied show changes of the same character as the vessels which are supposed to be immediately affected by the injury. In some cases we are not able to see in what way this influence extends to the vessels. The only way in which it is possible to study the effect of injurious agents on the cells alone is in the unicellular organisms. Few of the changes which we see in these organisms have any analogy with those seen in higher animals. The power of regeneration of the protoplasm is infinitely greater, and the single cell can perform all the functions which in higher animals are relegated to a great many tissues and cells.

In most tissues of the body and in most situations the injury is followed by certain changes which are partly subjective and partly objective, and the more conspicuous of these have been singled out and regarded as the cardinal symptoms or signs of inflammation. These are heat, redness, swelling, and pain. The presence of these signs and their degree, as a whole or considered singly, depend upon a great many factors. Increased heat in the area affected, which is such an important sequence of an injury on the external surface of the body, will be entirely absent in an internal organ. Redness will be absent in a non-vascular tissue, and even in a vascular organ the part most affected by the injury may often be recognized by its pallor. The degree of swelling will depend upon the character of the tissue, and its greater or less capacity for distention; it may be absent, or be present to a greater degree in an adjoining tissue which was not immediately affected by the injury. Pain is a wholly subjective phenomenon and its presence and intensity depend not only upon the character of the tissue which is affected but also upon the individual.

These phenomena can best be studied by producing varying degrees of injury in some vascular tissue which is capable of continuous observation. The ear of an albino rabbit is admirably adapted for this purpose. The whole series of changes may be produced by immersing the ear in water of 53° C. for three minutes. By varying the duration of immersion or the temperature of the water any degree of injury up to complete destruction of the tissue may be produced. Variations of a degree in the temperature of the water will have a marked difference in the result. At the beginning of the immersion close observation may show a slight pallor of the ear which soon gives place to redness. The redness is perceptible on withdrawing the ear from the water, and it gradually increases; even in the beginning it exceeds the redness produced by the physiological vascular dilatation. Arteries and veins are dilated as compared with the normal ear and the homogeneous redness shows the dilatation of the capillaries. The red has a bright, almost arterial

color in the beginning, but this in a few hours gives place to a dusky red color. If the immersion has extended to only the upper half of the ear, the general intense redness will extend slightly beyond the area of immersion; but the dilatation of the large vessels, both arteries and veins, will be seen in the lower half of the ear. On taking hold of the two ears increased pulsation can be felt in the injured ear, and on noting the temperature of the injured ear it will be found from 1° to 3° C. warmer than the normal. In addition to the general diffuse redness there may appear small, intensely red foci which, unlike the diffuse redness, cannot be made to disappear on pressure. Another very striking phenomenon is that the periodic flushing of the ear due to the alternate contraction and dilatation of the arteries is absent in the injured ear; the redness is continuous. It is perfectly evident from this that immediately following the injury there is dilatation of the arteries, and more blood is brought to the ear and more flows through it and is discharged by the dilated veins. The increased rapidity of flow is shown in the bright color approaching that of arterial blood, and in the increased temperature, the blood in the rapid circulation losing neither its oxygen nor its heat. The small red foci mark minute blood extravasations in the tissue. If the experimenter expose his hand to water of the same temperature the same phenomenon will be observed. By allowing the hand to remain in the water for periods varying from a few moments to one sufficiently long to induce distinct pain, different degrees of hyperæmia will be produced. It is temporary if the immersion has been short, or may continue for some hours if the immersion has been for a longer time. There is also a sensation of increased warmth and of increased fulness and tension in the hand. Continued observation of the ear shows another change which develops more slowly than the redness: the ear becomes swollen. The swelling begins to appear a few hours after the immersion and increases in degree up to twelve hours or longer, dependent upon the degree of the injury; it finally becomes so great that the animal is no longer able to keep the ear erect. There is a general diffuse swelling and on the inner surface of the ear are seen small blebs filled with a fluid which has come from the tissue and pushed up the horny layer of the epidermis before it. These blebs often rupture, and crusts are found on the surface due to the drying of their contents. With this swelling of the tissue there is evidently pain, for the animal shows uneasiness when the ear is handled and avoids contact with surrounding objects.

The actual condition of the tissue may be seen on microscopical examination. Small pieces of the tissue can be cut out and instantly killed by placing them in corrosive sublimate or in Zenker's fluid. The normal ear shows in the middle a thin lamella of hyaline cartilage with a thin perichondrium on each side of this. In the lower part of the ear there is a thin layer of striated muscle. Then comes on each side a layer of fibrous tissue which is thicker on the outside of the ear, and in this the hairs and their glandular appendages are embedded. On the inside of the ear the hairs are small and few in number and there are a few small glands not connected with the hairs. Twelve hours after the immersion the section may be twice as thick as the normal, or more. The thickness is most marked on the outside of the ear and is due to swelling of the connective tissue. The fibres in this are separated and often some granular coagulum is seen between them. A much greater number of cells is found in the tissue. The cells are most numerous on the inside of the ear, and on both sides are chiefly collected beneath the epidermis. Numbers of them will also be found within the small blebs on the inner surface. The vessels are dilated and filled with blood. The capillaries in sections are made out with some difficulty, and only in the tissue close beneath the epidermis. The larger vessels are adjacent to the cartilage and on the outer side. Not only are the arteries and veins dilated, but also all the large lymphatics, which are made out with difficulty in the normal ear, are enormously dilated and may be double the size of the large veins. They usually contain some granular coagulated material and a variable number of cells.

The ear is not the most suitable tissue for the observation and study of the finer details and progress of the changes, owing to the difficulty of the examination of the vessels. The gradual development of the vascular phenomena may best be followed in the mesentery of the frog. In a curarized male the abdomen should be opened on the left side, a loop of the intestine withdrawn, and the mesentery exposed under the microscope on a suitable carrier. Care must be taken to keep the tissue moistened with salt solution and in as natural a condition as possible. Stretching or twisting must be avoided as this will easily interrupt the circulation in the thin-walled veins. It is not necessary to injure the tissue in any way, for the necessary manipulation for exposing the part and keeping it outside the body inflicts sufficient injury to produce all the phenomena. It is probably impossible to observe a normal circulation in a mesentery so treated, as hyperæmia to a certain degree immediately follows the exposure and handling of the intestine. As seen under the microscope, there is a gradually increasing dilatation of the arteries with a more rapid flow in all the vessels. The axial and plasma zone in the large vessels is very evident, and the flow in the capillaries may be so rapid that it is difficult to distinguish the single corpuscles. The red corpuscles in the larger vessels form a red core in the centre and the white corpuscles roll along in the clear space outside of this. The dilatation of the vessels, with increased rapidity of flow, lasts a variable length of time, depending upon the care which has been exercised in exposing the mesentery. All of the phenomena develop more slowly and are more easily studied the greater the care taken to avoid injury.

In a short while the condition changes; the dilatation of the vessels continues, but the rate of flow in all of them is diminished. It is also seen, and this is a point which is often lost sight of, that the relative number of white corpuscles in the vessels is increased. Despite the dilatation of the vessels the rate of flow is diminished, the axial zone disappears, and the corpuscles fill the vessels. The white corpuscles, however, retain their position in the periphery of the stream and accumulate in such numbers that the inner wall of the vessel becomes paved with them. All the corpuscles pass along more slowly, but the white corpuscles much more slowly than the red, so that more accumulate in the vessels. As the process advances, many of the white corpuscles remain stationary and while attached to the wall undergo amœboid movements. Some after remaining for a time are rolled away by the stream, others become permanently fixed. Although this accumulation of leucocytes is more marked in the veins it takes place to some extent in the capillaries also. Very many more are now seen in these vessels than at the beginning of the experiment. If certain of the amœboid leucocytes attached to the veins are watched they may be seen to pass through the wall of the vessel into the tissue outside. A small protoplasmic protrusion is first seen outside the vessel opposite the point of attachment of the cell, and this gradually increases in size, while the part inside diminishes, until the whole corpuscle has passed without. (Plate XXXIV., Fig. 5.) Outside the vessel the active amœboid movements continue and the corpuscle creeps of its own motion through the tissue, although it may also be seen to be moved passively. This process of emigration takes place now with such rapidity that the vessel is soon surrounded by leucocytes which have passed out. It takes place chiefly in the veins and to a much less extent in the capillaries. It is generally considered that it does not take place from the arteries at all, but I have many times found the mural arrangement of leucocytes and active emigration in comparatively large arteries with thick muscular walls, although I have never seen it in the small arteries which immediately supply the capillaries. It cannot be seen to take place in the arteries of the frog's mesentery on direct observation of the circulation, nor have I ever seen any indications of it in prepa-

rations of the rabbit's mesentery made at varying intervals after injuries produced in a number of ways. All this time the circulation has become progressively slower, and finally in places, and in the vessels which are distributed to the mesentery itself, it may cease. The vessels now become packed with corpuscles and a to-and-fro movement is often seen in them. The corpuscles themselves seem to lose their outlines and form a solid mass inside the vessels, while the white corpuscles are passing through, and usually some time after this has begun, the red corpuscles also pass through. This process is much more difficult to follow, but single corpuscles may occasionally be seen in the act of emigrating. It may take place from vessels in which the circulation has ceased, and in some cases numbers pass through at a single spot. When the single corpuscles pass through the process seems to take place very much in the same way as in the emigration of the white. A small thin point first protrudes through the wall and the rest of the corpuscle follows.

The same series of changes which take place in the mesentery of the frog can be seen in the mesentery of the mammal, although here a complicated apparatus is necessary in order that the mesentery may be observed under conditions approaching the normal. An excellent way is to kill animals at various times, from minutes to hours, after injury to the mesentery by the injection of irritating substances, and then to make microscopic preparations of the mesentery. The tissue can be instantly killed and hardened, and the actual conditions thus studied much better than during life. The different pictures of the process which are given in this way are extremely satisfactory. All the details of emigration and diapedesis can be studied, all the varieties of leucocytes can be differentiated, and the part each plays can be determined. (Plate XXXIV., Figs. 1, 2, 5.)

For the study of changes which take place in non-vascular tissues the cornea may be chosen. The literature of acute inflammation of the cornea is enormous. It has been the battlefield on which the conflict as to the character and origin of the cells which appear in the tissues in acute inflammation has been fought. The accessibility of the tissue and its simplicity admirably adapt it for this study. The cornea is covered with the conjunctival epithelium. Its tissue is composed of straight fibres of white fibrous tissue which lie in planes, all the fibres of the same plane being parallel. Between the fibres there is a cement substance which stains brown with nitrate of silver. The cells of the cornea, connective-tissue cells, are much branched, flattened antero-posteriorly, and lie in spaces of the same shape between the fibres. All the spaces open into one another and constitute a series of channels through the tissue which communicate with the lymphatics and lymph spaces in the surrounding parts. There is also a series of more definite lymphatic channels around the nerves which communicate with the cell spaces.

When the corneal tissue is injured to a sufficient degree great numbers of new cells are found in it. The character and origin of these new cells were long in dispute, but it may now be regarded as certainly established that in the early phases of the process these new cells are leucocytes which come from the blood by emigration and make their way into the tissue. If the centre of the cornea has been injured either by cauterization or by inoculation with any one of a number of bacteria, the cells will be found in the lymph spaces of the periphery and also around the central injury. In the latter place a great many of them come from the conjunctival secretion, which after injury to the cornea contains numbers of leucocytes. If flat sections of the surrounding sclera be made, the same changes which we have seen to take place in the mesentery will be observed. It is necessary, however, for the injury to be of a certain degree, and those injuries in which the tissue is torn are more apt to be followed by the typical phenomena. Very slight injuries affecting only the conjunctival surface, or even extending to the corneal lamellæ immediately below this, need not produce any but the slightest inflammatory lesions in the cornea proper. The leucocytes may be entirely absent.

It is only within comparatively recent years that we have been able to recognize definitely the varieties of leucocytes and the part which they severally play in inflammation. The distinctions are made in part on the morphology of the nucleus and in part on the character of the granules contained in the protoplasm. In the blood of the rabbit the following varieties of leucocytes are found, following the classification of Brinckerhoff: Amphophiles, 40 to 50 per cent.; lymphocytes, 40 to 50 per cent.; large mononuclears, 5 per cent.; mast cells, 4 per cent.; eosinophiles, 1 per cent. The main difference in the blood of the rabbit, as compared with that of man, is the greater relative number of lymphocytes in the rabbit's blood. The amphophiles in the rabbit correspond in all respects save the character of the granulation with the neutrophiles or polynuclear leucocytes in man. The granules of the amphophiles in the rabbit stain with eosin, but not so intensely as the eosinophiles, and they are much smaller. We shall refer to these cells in the rabbit as amphophiles and in man as neutrophiles. The granules are very much more evident in the amphophiles of the rabbit than in the neutrophiles of man.

The leucocytes which most concern us are the amphophiles or neutrophiles. These usually constitute the majority of the leucocytes in the exudation and in some cases they may be the only ones found. (Plate XXXIV., Fig. 3.) They are the first cells to appear in the inflamed cornea, and when the injury is produced by a chemical agent, no other cells are found in the first eighteen hours. They are actively amœboid and may be found in the tissue a considerable distance from the vessel from which they emigrated. They can be easily recognized both in the tissues and in the vessels and there is less doubt concerning them than in regard to any other of the leucocytes. There is very much more doubt regarding the mononuclear leucocyte. The amphophile leucocyte of the rabbit or the neutrophile of man may be regarded as almost the most distinctive cell in the body. It originates in the bone marrow, and when once formed it is not certain that it undergoes any but degenerative changes. We recognize other cells in part by their morphology, in part by their situation and relations with the tissue, but the amphophile leucocyte is characteristic in all situations. When it is found in the tissues under either normal or pathological conditions, we know it has been brought there by the blood and has reached its present location by emigration from the blood-vessels. The mononuclear leucocytes are much less well known, and their morphological characteristics are less marked. They are found in the blood in much smaller numbers and they certainly may be formed in a number of places. The general tendency seems to be to regard them as endothelial in origin and as such they may be formed in any tissue possessing endothelium, and there is scarcely any tissue in the body in which endothelium does not exist. Their numbers in the blood are not subject to the variation which characterizes the other cells. In the inflamed tissues we know that they certainly in part come from the blood and in hardened preparations they may be found in the act of emigration, but it is infinitely more difficult to see this than it is in the case of the polynuclear leucocytes. They are usually present in small numbers, certainly in much smaller numbers than the other leucocytes, but in rare cases they may constitute the great mass of cells in the exudation. I have seen cases of pneumonia in which all the cells in the alveoli were of this type. It is difficult, however, to distinguish them from the cells derived from proliferation of certain of the epithelial tissues, notably the epithelium lining the alveoli of the lung and the kidney epithelium. In the cornea I have never found them in any number until twenty-four hours after the injury and chiefly around the periphery. They are much less actively amœboid than the polynuclear leucocytes. The same thing is true of the inflamed mesentery. In no experimental inflammation are they found in such great numbers as they are occasionally found in man. These cells can easily

be distinguished from the other varieties of leucocytes by the character of the nucleus and protoplasm. The nucleus is in a single mass and varies in shape, being in different cases round, oblong, or curved. It may have a horseshoe shape with a central constriction, but is never separated into the clumps which are so characteristic of the polynuclear leucocyte. It stains less intensely, and the chromatin is in small masses. The protoplasm is homogeneous or very finely granular and there is no well-defined cell membrane. It seems certain that all of these cells which are found in the cornea reach there from without, but it is not certain that they are all due to emigration. In tissues of more complicated structure it is probable that they are, in part at least, formed from the endothelium of the blood and lymphatic vessels. I have seen in diphtheria the sinuses of a lymph node filled with these cells and have traced their origin to the lining endothelium.

Along with these cells and a little later other cells begin to appear in the inflamed area. These are the lymphoid cells. They are easily distinguished from the other varieties by their small size and their relatively large and brightly stained nucleus. It is also very difficult to explain the origin of these. In the cornea they are never present in any considerable numbers, and then only around the outer edge, but they are found in very great numbers in the surrounding tissue. They are feebly amœboid and their presence in the tissue is to be accounted for rather by their being conveyed passively in the lymph stream than by their own active movement. In all my study of inflamed tissues I have in only two or three instances undoubtedly witnessed their emigration, as shown by cells partly within and partly without a vessel. In the spleen and in the lymph nodes they are not infrequently seen engaged in the walls of the vessels, but whether they are passing from the vessel or into the vessel is uncertain. In the inflamed mesentery of the rabbit they are found in the blood-vessels in considerable numbers after forty-eight hours, but not in such numbers as to explain by this source alone the large numbers of them which may be present in the tissues. In a tissue which contains numerous lymphatics numbers of them are found in these vessels, and it has been supposed that they may reach the inflamed area by this route; but it must be remembered that the direction of the lymph flow is from and not to the inflamed area. The subconjunctival lymphatics around the inflamed cornea may be found filled with them. They may be formed from similar cells in the tissues. A few will always be found in normal tissues in the vicinity of the vessels, and they increase by division, but no one of these means nor the combination of all of them has seemed to me sufficient to account for the great numbers of the cells which may occasionally be found in the late stages of inflammation. Ribbert believes that they are chiefly produced locally by proliferation of the small masses of lymphoid tissue which are frequently found in the tissues, but there are several objections to this view. Such small masses are very infrequent in the mesentery; and in the pleura, where they are found in abundance, there does not seem to be any enlargement accompanying acute inflammations of this structure and of the adjoining lung.

The next leucocyte to be considered is the eosinophile. It is easily distinguished from the other varieties by the nucleus and by the presence of the oblong granules which stain intensely with eosin. In most cases these cells are found in very small numbers. They come from the blood-vessels by emigration and may be seen in the act. I have seen in one specimen an eosinophile cell passing through the wall of a small vein. They are more numerous in the latter stages of inflammation and are extremely variable in number. They appear to be more feebly amœboid than the others. In the cornea I have only occasionally seen them and then never far from the periphery. In one specimen of the mesentery, twenty-four hours after inflammation excited by the injection of one per cent. turpentine, they form the most numerous of the leucocytes in the tissue. In another case considerable numbers of them were found in a specimen made six hours after the injury. In the inflamed tissue around certain animal parasites, notably trichinæ, they may be the only variety of leucocytes found. In a case of echinococcus cyst of the breast in which there was intense inflammation in the surrounding tissue of the mamma they were found in enormous numbers.

The leucocytes in wandering through the tissue in part follow the lymphatic spaces, in part they leave these and make paths for themselves between the fibres. In the cornea, while in the lymph spaces and in the comparatively wide communication between these, they preserve their form to a great extent; when between the fibres they may stretch out into lines which are as thin as the fibrillæ themselves. (Plate XXXIV., Fig. 4.) Few tissues offer a definite bar to their passage. In the cornea I have never found them engaged in the densely hyaline membrane bounding the anterior chamber. Inflammation of the cornea does not involve the anterior chamber except in the case of infectious inflammations combined with necrosis, and when necrotic even this membrane will not prevent their passage. When wandering along the thin spaces of the cornea the separate portions of the nucleus may come together and form a thin rod within the corpuscle, or the widely separated nuclear masses may be connected by a nuclear filament so thin that a high power is necessary to demonstrate it. When wandering in this way the nucleus is drawn to one end of the corpuscle and toward the front end, that is in the direction of motion. In a normal corpuscle there is never a complete separation of the various parts of the nucleus; when this takes place it is evidence of degeneration. They pass through the dense membrana propria below the epithelium of the trachea, and apparently through small spaces in this, for while they are engaged in passing through it they are drawn out into filaments.

The leucocytes, especially the polynuclear forms, may undergo various changes in the tissues after they have left the vessels. These changes are interesting in themselves, and also interesting from the interpretations which have been placed upon them. They may undergo fragmentation in a number of ways. The cells may lose a part of their protoplasm without any apparent degeneration. It is not uncommon to find in the cornea small round masses of protoplasm containing the same oxyphilic granules directly in the wake of the corpuscle. We may find a leucocyte with such small masses almost constricted off. In some cases the fragments contain relatively fewer granules than the main body of the leucocyte. The fragments are not formed by a protrusion of the protoplasmic contents through the cell membrane, but the fragments have a membrane around them like the leucocyte. In the mesentery also these fragments may be found in great numbers. The leucocyte may undergo degenerative fragmentation. This is always combined with degenerative change in the nucleus. In imperfect hardening and staining, and especially in dried specimens of blood, the nucleus appears to be solid and without structure. In reality it is not so, the appearance being due to the abundance and the intense staining of the chromatin. In the fragmenting leucocyte the nucleus is solid and intensely stained. The fragmentation may assume the character of direct cell division. The cell may divide into two parts, each containing a portion of the degenerated nucleus. The whole mass may break up into a number of pieces, each of which may contain a small round particle of the nucleus, or the nuclear fragments may be found together and without any connection with the fragments of the protoplasm. There is no true proliferation of the leucocytes. These fragments, particularly those enclosing particles of chromatin, have been the basis of many of the descriptions of protozoa in the tissues. They form many of the objects which have been described as the parasites of cancers, and are with little doubt some of the things which have been described as parasites in smallpox and vaccine vesicles. I have never seen similar forms of degeneration in the mononu-

EXPLANATION OF
PLATE XXXIV.

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FIG. 1.—Normal Mesentery of Rabbit, Showing Size of Small Artery, Vein, and Capillaries. The artery curves across the vein, giving off a capillary; a capillary also enters the vein. 8 mm. Zeiss.

FIG. 2.—Artery, Veins, and Capillary Network of Rabbit One Hour after Injection of One-per-cent. Nitrate of Silver. Intense congestion with abundant diapedesis from veins and capillaries. 16 mm. Zeiss; half magnification of Fig. 1.

FIG. 3.—Acute Salpingitis, Showing Infiltration of Leucocytes in Tissue of the Papillæ of Fallopian Tube. 8 mm. Zeiss.

FIG. 4.—Edge of Eschar in Cornea after Forty-eight Hours, Showing Infiltrating Leucocytes in Corneal Tissue between the Fibrillæ. 16 mm. Zeiss.

FIG. 5.—Small Vein in Mesentery of Rabbit Four Hours after Injection of Water at 52° C., Showing Rapid Emigration.

PLATE XXXIV

FIG. 1.

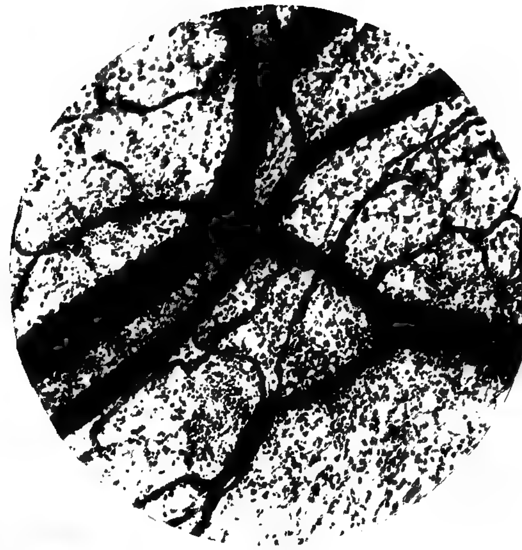

FIG 2.

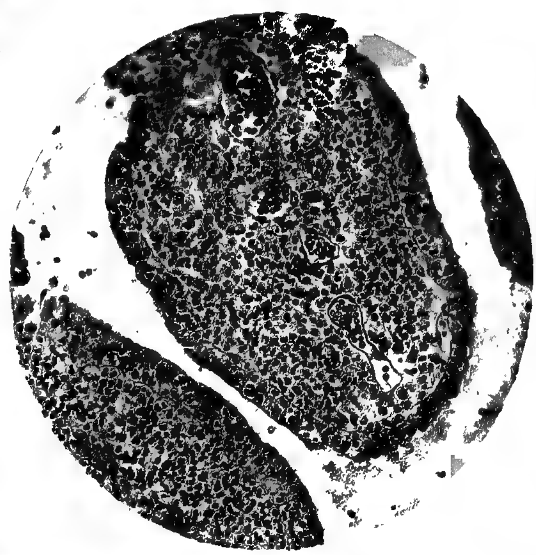

FIG. 3.

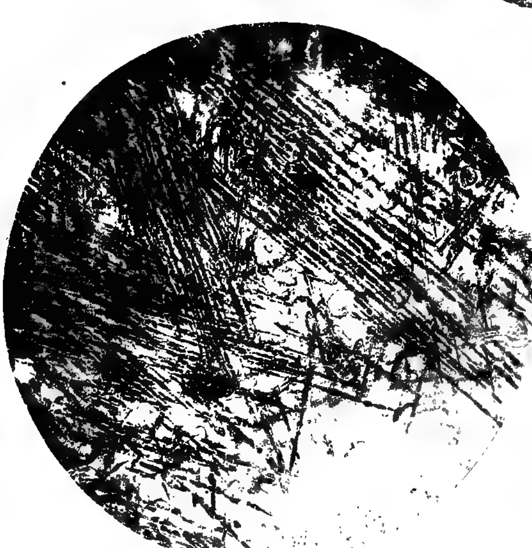

FIG. 4.

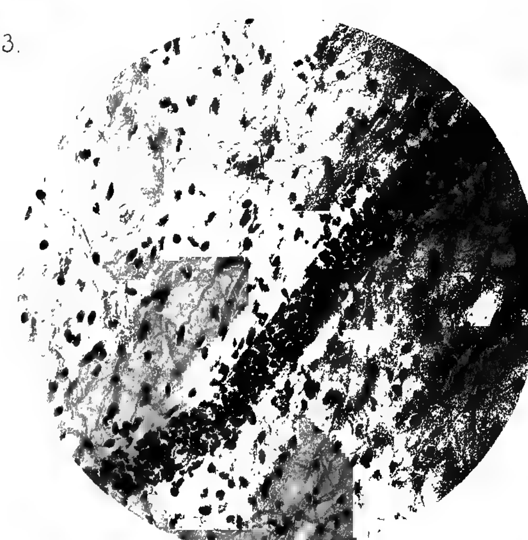

FIG. 5

ACUTE INFLAMMATION.

clear leucocytes. These have not such power of amœboid motion nor such capacity for penetration. Ordinarily but little degeneration is seen in the lymphoid cells in the tissues, and these seem to undergo degeneration chiefly when in large masses and under the influence of strong toxins. The intensely stained solid nuclear fragments to which they give rise are very conspicuous. The fragments very often have a distinctly crescentic shape.

The red corpuscles in the exudation vary greatly in number, this depending in normal tissues chiefly on the character of the injurious agent used. In the cornea it is not possible to produce any considerable hemorrhagic exudation, although in most cases a number of red corpuscles will be found in the tissue around the vessels. In the mesentery an abundant hemorrhagic exudation may be produced by the injection of nitrate-of-silver solution into the peritoneal cavity. (Plate XXXIV., Fig. 2.) The red corpuscles are found chiefly around the vessels from which they have come, but they may be washed to a distance by the lymph streams. In the cornea they may be found in the cell spaces at quite a distance from the periphery. In diphtheria I have often found them between the epithelial cells of an intact mucous surface. As they have no amœboid power of their own they must be carried passively by the lymph stream, and their presence in such places gives an indication of the force and the amount of the lymph stream. The red corpuscles, like the leucocytes, may undergo fragmentation, and in the inflamed mesentery I have found the red corpuscles around the vessels broken up into round fragments.

Do the blood platelets take any part in inflammation? I do not believe that these exist as such in the normal blood. For a long time I have been examining the blood in normal vessels to determine this point and have never found them. The view of Arnold that they are formed from red blood corpuscles is probably correct. In the inflamed mesentery of the rabbit I have occasionally found numbers of them in the small veins and in the adjoining tissue. It cannot be decided whether they emigrate from the vessels or whether they are formed *in situ*.

Along with the cells there is a considerable amount of fluid exudation from the vessels, and the swelling of the tissue is chiefly due to this. The fluid passes into the tissue, distending first the lymph spaces and then saturating the tissue itself, forcing apart the connective-tissue fibrillæ. In the cornea the cell spaces and passages are thus made larger than normal. Occasionally a beautiful demonstration of the fibres of the cornea is given in specimens of the inflamed tissue stained with nitrate of silver. The fibres are all separated and the thin space between any two adjacent fibres is stained brown by the silver. The fibres are all of the same size and each plane is composed of a single thickness of parallel fibres. A very thin flat section of the cornea contains a number of these planes of fibres. In the mesentery also, in spite of the ease with which the fluid can pass to the surface and away, spaces may be seen between the fibrillæ. In the rabbit's ear the fluid chiefly collects in the connective tissue on the outside surface, and all the fibres are separated so as to form a loose meshwork. The passage of the fluid from the vessels begins before either the diapedesis of the red corpuscles or the emigration of the white, and continues much longer. An abundant fluid exudation may take place on a very slight injury to the tissue and without any cellular exudation. If a blunt instrument be drawn over the inner surface of the forearm making considerable pressure, a slight swelling becomes perceptible in a few minutes. In a circumscribed area of inflammation this exudation takes place in the border zone where the effect of the injury has not been sufficient to produce the cellular exudation. The amount of the fluid exudation and the relation between the fluid and cells depend upon the situation of the inflamed area. If this is deep down in the tissues so that the fluid cannot escape, but remains in the tissues, there will be relatively few cells present. If it is near the surface, the fluid may escape easily either to the surface of the body or into a cavity, and most of the cells may be left entangled in the tissue. In inflammation of the lung the fluid and cells also pass without trouble from the thin walls into the air spaces. In inflammation of the pleura or peritoneum the fluid passes into the large cavities and collects there; more leucocytes, however, are held back in the tissues than is the case in the lung. The skin offers a marked resistance to the passage of fluids through it. The exudation collects chiefly in the loose subcutaneous tissue distending the spaces, but it may pass through the lower layer of the epidermic cells, forcing up the horny layer in the form of vesicles filled with fluid. If the vesicle is ruptured the exudation may pass through to the surface, but this is usually prevented by the drying of the exudation and the formation of a scab. The smallpox vesicle differs from the ordinary vesicles; it is not produced by the collection of an exudation beneath the horny layer, but is formed deeper down in the epithelium, its formation being preceded by a degeneration of the epithelial cells. In some cases the entire epidermis may be elevated by the exudation. Most mucous surfaces, even when lined with stratified epithelium, offer little opposition to the outward passage of the exudation. As we have said, the exudation seems to pass with considerable force, for cells are swept along by it and may be carried into situations where they could not arrive by their own activity. Not only is the presence of red corpuscles in the upper layers of the epidermis to be accounted for in this way, but the force of the exudation is probably an important factor in the movement of the leucocytes. An excellent example of an almost pure serous exudation is given in sunburn. In this condition the subcutaneous tissue may be greatly distended with such an exudation, and examination of the fluid of the vesicles will show very few leucocytes. Such an exudation represents the reaction following the slighter forms of injury.

If inflamed tissues are carefully examined a varying amount of fibrin will be found in nearly all. It will be absent in slight degrees of inflammation and in the severer forms of suppurative inflammation. The amount, situation, and character of the fibrin vary in different cases and the factors which influence these conditions are not definitely known. The fibrin is formed from the fluid exudation after it has left the vessels. The conditions for its formation are present when the exudation comes in contact with necrotic cells. These may be either the cells of the tissue or broken-down leucocytes. The fibrin is formed by the fibrinogen of the serous exudation in the presence of a ferment produced by the degenerated cells. When it is not formed under such conditions or when its formation is extremely feeble, as in the suppurative inflammation, this is due to the presence of substances which prevent the chemical reaction by which it is formed, or lead to its solution when it is formed. The fibrin appears under the most varying forms. It may take the form of a network of the finest filaments or the filaments may be broad and hyaline. Within the tissues it may appear in stellate figures, the filaments radiating from a centre. In the centre a small stained body is often seen which represents the remains of the nucleus of a degenerated cell. Such stellate fibrin figures are found in great numbers in the subcutaneous tissue of the inflamed ear of the rabbit and in the submucous tissue in diphtheria. The fibrin is also found on inflamed surfaces where it forms connected masses. On the surface of the pleura it may be present as a layer 1 cm. or more in thickness, or it may be in such small amounts as to constitute only a faint granulation. New interest was given to fibrin formation some years ago by the statement of Neumann that it is formed not on but in the serous surfaces, and that most of what are regarded as fibrin filaments really are connective-tissue fibrillæ which are transformed into fibrin. A careful study of the process has shown that there is a relation between the connective-tissue fibrillæ and fibrin formation. The fibrillæ are not converted into fibrin, but fibrin is deposited upon and probably in them. Under such conditions the fibrillæ become swollen, refractive, and hyaline, and give the microchemical reactions of fibrin. This fact may be

more easily demonstrated in diphtheria than in any other process. The membrana propria beneath the false membrane on the trachea may show patches of this, and extending from it into the tissue beneath there are swollen hyaline fibres which may be shown by appropriate stains to be continuous with unaltered connective-tissue fibrillæ. On serous surfaces Ribbert has shown that the first appearance of the fibrin takes the form of small projections between the endothelial cells. The great mass of fibrin is on the surface and is a true exudation, but there may be a slight fibrinoid metamorphosis of the tissue, and the fibrin formed in this way may be connected with the membrane on the surface. The relation of the endothelium to the fibrin formation varies. Usually no trace of this layer will be seen, or small areas of intact endothelial cells may be found. In a case of fibrinous peritonitis following amœboid dysentery the endothelium was found almost everywhere beneath the false membrane, the cells being greatly swollen and proliferating. In rare cases larger or smaller spaces lined with large cells of a typical epithelial character may be found in the false membrane on serous surfaces. These are connected masses of the surface endothelium which have been lifted off by the exudation coming from beneath and have become enclosed in the fibrin mass. On mucous surfaces the fibrinous exudation may form dense elastic membranes which may be in some cases stripped off in large pieces, while in others the membrane clings more closely and can be removed only in fragments. In situations where the membrane has been formed on a dense membrana propria the separation is easy. It is due to the presence of a membrana propria that in the trachea the false membrane formed in diphtheria is easily removed, while in the pharynx where there is no membrana propria it adheres. On mucous surfaces the formation of the false membrane is due to a combination between the exudation coming from below and necrosis of the surface epithelium. Microscopically it is easy to distinguish two definite forms of pseudomembrane. In both there is a reticulum, but in one case the spaces are small and the reticulum is broad and highly refractive, and in the other the spaces are larger and the reticulum has the character of fibrillar fibrin. Even macroscopic differences in the membrane can be seen. The first, which may be distinguished as the hyaline membrane, is formed on mucous surfaces covered with stratified epithelium. The epithelial cells remain and are converted into fibrin very much in the same way as in the fibrinoid metamorphosis of the connective tissue. In a case of membrane formation in the œsophagus it was possible to trace the formation of fibrin around necrotic cells and the conversion of these into the membrane. In the trachea the epithelium is cast off and takes no part in the fibrin formation other than supplying by its necrosis the necessary fibrin ferment. In many cases the membrane shows a peculiar architecture, the fibrin being arranged in definite arches and pillars, the latter being attached to the tissue beneath by a broad foot or connected with the fibrinoid connective tissue. Large numbers of both white and red corpuscles may be found in the membrane, the dark color which it sometimes shows being due to the presence of the latter. When once formed, the fibrin may extend over an intact epithelial surface and areas of completely healthy epithelium may be found beneath it. In the intestinal canal a perfect fibrinous exudation is rarely met with. What appears macroscopically as fibrin is composed of necrotic cells and tissue, with but slight admixture of fibrin. The best examples of fibrinous exudation in the digestive tract are found in the stomach. It is probable that the formation of fibrin is influenced by the character of the fluid which comes from the vessels, its varying richness in fibrinogen, and conditions which this exudation meets in the tissues. We know very little about the character of the exudation fluid as it comes from the vessels. Analyses have shown that it contains about the same amount of salts and is richer in proteids than the blood serum; it is, however, no longer as it came from the vessels, but is a tissue fluid, and it may have been modified by conditions it met with in the tissues. In the tissues it differs greatly in concentration and probably in other ways, as is shown by the character of the coagulum formed in rapid hardening. In some cases there is a dense granular coagulum, in others scarcely any coagulum is found.

The exudation may be converted into a hyaline mass without a trace of structure. Such hyaline masses may be found in the alveoli of the lung in various forms of pneumonia but particularly in tuberculous pneumonia. In this the hyaline material is most apt to be found in the anterior borders of the lung. To what extent the hyaline masses found in the tubules of the kidney in various forms of renal disease represent a metamorphosis of an albuminous exudation is not known. We know that these casts are certainly formed by the coalescence of hyaline drops which are formed in the degeneration of epithelium, but this may not be the only mode of formation. They are most frequent in those forms of renal disease in which hyaline epithelial degeneration is common, as in the amyloid kidneys and in some forms of acute nephritis, but they are also found when hyaline epithelial degeneration is not conspicuous. It is not known whether such changes in the exudation are due simply to its becoming more concentrated or whether there is a further chemical change.

Suppurative inflammation is a special form in which an exudation is produced which is especially rich in cells, and in which there is a strong inhibition to the formation of fibrin. (Plate XXXIV., Fig. 3.) It differs from other forms of inflammation also in its etiology. Varying degrees of injury of the tissue, even when produced by the same agent, may give a serous, a hemorrhagic, or a fibrinous inflammation, but without the addition of a specific cause the inflammation will not result in suppuration. In this the exudation may form for itself a cavity in the tissues, called an abscess, in which it is confined. The content of the abscess is called pus. Probably without exception, under natural conditions suppurative inflammation is produced by the action of bacteria. A great number of bacteria may produce pus, but certain micro-organisms are so generally found in connection with suppuration that they are known as the pyogenic or pus-producing bacteria. The most common of these is the Staphylococcus aureus. Exactly what the conditions are under which certain bacteria, which ordinarily act in an entirely different manner, produce suppuration is not known. This action may be due to some condition in the tissues affected or it may be due to some peculiar change in the character of the organisms. Certainly we do not know any distinct varieties of either the typhoid or the tubercle bacillus which are associated with suppuration. Even such an organism as the pneumococcus or the diphtheria bacillus, with whose action we are accustomed to associate a fibrinous exudation, may—the former not infrequently—produce suppuration. Experimentally an inflammation closely resembling suppuration may be produced by croton oil. After injection of this into the subcutaneous tissue or muscle there is formed in it a cavity which contains pus, that is, a fluid containing great numbers of polynuclear leucocytes, but without fibrin. The various steps in the formation of the abscess can be followed experimentally by injecting staphylococci into the tissues or inoculating the cornea with them. After injecting staphylococci into the ear vein of a rabbit abscesses are found in the organs in large numbers. It is difficult to explain the situation of these abscesses. They are found most frequently in the kidney, and next in frequency in the heart and in the anterior abdominal wall; they are very rarely found in other situations, although the organisms must be carried everywhere by the blood. The formation of abscesses in these situations is probably to be accounted for by the conditions of the circulation favoring the accumulation of the bacteria in the vessels. The early stages are more easily seen than the fully developed abscesses, for in most cases the animal dies before these are actually formed. The first thing in the production of the abscess is the collection of a mass of the cocci,

occluding a small vessel, usually a vein. It is not probable that this large mass is brought to the tissue as such, but single organisms lodge in the wall of the vessel and this becomes filled by their gradual growth. The immediate effect of the presence of the bacteria is the production of an area of necrosis around them. The extent of this area of necrosis varies slightly according to the size of the occluded vessel and the number of microorganisms. The necrotic area appears macroscopically as a small white speck. The elements of the tissue are obscured but can be distinguished. The nuclei no longer stain, but do not generally undergo degeneration or break up into chromatin fragments. The capillaries in the area are not visible; they are not occluded by fibrin but appear to be compressed by the swollen tissue. No leucocytes are present. There is simply necrosis of the tissue. This is well shown in the cornea. After central inoculation with virulent staphylococci a white speck is formed which under the microscope is seen to be composed of central masses of cocci in the corneal spaces around which is an area of necrotic corneal tissue. The necrosed corneal corpuscles are contracted into irregular clumps but can be distinguished. Either around the necrotic area or just within it there are large numbers of leucocytes closely packed in the tissue and forming a definite wall. The surrounding blood-vessels are congested, show a mural arrangement of leucocytes, and emigration takes place rapidly. In most cases the leucocytes are exclusively polynuclear. We are rarely able to trace the beginning of abscess formation in man, as we can experimentally in animals, for the abscesses are usually met with in a later stage of formation. In man we very frequently find, particularly in the liver, but also in the kidneys and spleen, masses of staphylococci in the vessels without necrosis or any evidence of reaction around them. I have also occasionally found in the kidneys and in the heart small abscesses similar in all respects to those produced experimentally in the rabbit.

The next step in the formation of the abscess is the softening of the necrotic tissue and its invasion by leucocytes. In an early stage there is no invasion. The wall of leucocytes is perfectly definite and they may form a complete circle with the bacteria in the centre. There is produced by the bacteria something which repels the leucocytes in the beginning while the necrotic tissue attracts them. It is probable that the bacteria in the centre may produce a toxin which paralyzes the amœboid activity of the leucocytes. Some are certainly destroyed, but in most of them no evidence of degeneration is seen. I have never been able to follow microscopically the various steps in the softening, but it seems to be a complete liquefaction of the tissue. In the cavity thus formed the leucocytes and bacteria become free and the latter are then taken up by the leucocytes in numbers. To no one who is acquainted with the degenerative process in leucocytes can there be any question that the process is a true phagocytosis. Perfectly unchanged leucocytes will be found with great numbers of bacteria within them. The polynuclear leucocyte is essentially phagocytic for the pus organisms and pneumococci, but I have never found these enclosed within either the large mononuclear leucocytes or the eosinophiles. It is not possible to be certain with regard to other bacteria. Large numbers of leucocytes are destroyed in the pus, and even those in the surrounding tissues may be destroyed. They seem to undergo the same sort of destruction as those in the mesentery, but the process cannot be so easily followed. The destruction is recognized chiefly by the fragments of chromatin. Certain organisms seem to exercise an especially destructive action on the leucocytes. In glanders, masses of fragmented polynuclear leucocytes may be found in tissue which shows but little degeneration. In the contents of the muscle abscess formed in human glanders not a single normal leucocyte may be found. These abscesses are also characterized by the complete absence of the regenerative processes in the surrounding tissue; of this I shall speak later.

The process of abscess formation after the injection of croton oil is very similar in most respects to that produced by staphylococci. The tissue which is immediately acted on by the oil is destroyed. If the injection has been made into the muscle and the latter is examined after forty-eight hours, a sharply circumscribed area is found in which the tissue closely resembles the necrotic area around bacteria. The muscle fibres are swollen and hyaline, the nuclei do not stain, and neither vessels nor cells can be recognized. Immediately around this area of complete necrosis is the enveloping wall of leucocytes. In the midst of the leucocytes and on the side toward the normal tissue there may be numerous single necrotic fibres, which become filled with leucocytes, but there is not complete necrosis of all the elements of the tissue. It seems that here also the leucocytes are attracted to the necrotic tissue, but there is something in the central mass which repels them. The softening of the tissue takes place first in the area of intense leucocytic infiltration around the necrosis, and the necrotic mass may remain in the cavity as a sequestrum, or it may become softened and disintegrated. I have found the central necrotic mass produced by a turpentine injection remain in the tissue as a foreign body and undergo slow absorption by granulation tissue. A definite abscess cavity is not always formed in purulent inflammation. Certain tissues, especially loose connective tissue, undergo softening more easily than the denser tissue, and the softening may extend along these connective-tissue septa leaving the denser tissues. In this way the muscles may be dissected out. This result is favored by the course of the lymphatics by means of which the infectious agents may extend. In a racemose gland the suppuration may extend along the ducts and connective-tissue septa dissecting up the gland tissue proper. In some cases there may be a general purulent infiltration of the part with but little tendency to softening. In such cases small foci of leucocytes are found in the tissue. There is a great difference in tissues relative to the ease with which softening takes place. Elastic tissue is very resistant and may be found unchanged, cartilage is not softened. In a case which I recall of extensive abscess formation in an amyloid liver, the amyloid material was dissected out by the softening process and lay unchanged in the abscess contents. The absence of fibrin is generally considered one of the most characteristic features of purulent inflammation, distinguishing it from other forms of inflammation. Yet there may be considerable fibrin present in some situations, especially in suppuration occurring on serous surfaces.

The pain in inflammation is due to the pressure exerted on the nerves in and around the swollen tissue. The severity and the character of the pain are influenced by a great many conditions. Parts which are not ordinarily sensitive, such as the peritoneum, may become intensely so in inflammation. As a rule the denser the tissue, the less able it is to be distended by the exudation, the greater will be the pressure exerted on the nerves within it and consequently the greater the pain. It is for this reason that inflammation of the periosteum is usually intensely painful. In an acute inflammation the pain is often throbbing, there being exacerbations which correspond with the systole of the heart. This is due to a sudden increase of tension produced in the part by the blood driven into it by each heart beat.

So far we have spoken only of the exudation, the cells and fluids which are derived from the blood. But the tissues also participate in the process and the changes which take place in them are not secondary in importance to the circulatory disturbances. All the phenomena of inflammation are due to an injury of the tissue which is produced by the action of the causative agent. It cannot be due to injury exerted on the vessels alone, for these cannot be injured without injury to the tissue at the same time. The attempt has been made to regard all the phenomena as the result of vascular disturbance and to explain them partly on a physical basis. It is not always possible to estimate the degree of influence exerted on a tissue by an injurious agent. We can detect those injuries which lead to complete destruction and

necrosis of cells, and in certain other cases we can detect various forms of degeneration in cells; but there must be various degrees of injury which we cannot detect by changes in the cells and tissue. In the exposed mesentery of the frog all the phenomena of inflammation may be seen in a tissue which so far as we can tell is normal. The same thing is true of the action of mild irritants in this and other tissues. It is certainly possible that there may be alterations in tissues which we cannot recognize. Cohnheim has explained all the phenomena of inflammation by an assumed alteration in the walls of the vessels brought about by the injury. The primary condition, he thinks, is due to this, the vessels become more porous, allowing exudation to take place, while the accumulation of leucocytes in the vessels is due to an increased adhesiveness of the wall. He attributes the emigration of leucocytes and the diapedesis of the red corpuscles to the alteration in the wall and the effect of pressure. This theory attributes to the walls of the vessels a preponderance of activity which we are not warranted in assuming. It is the tissues which determine the character of the circulation in a part; a gland does not secrete because it receives more blood, but it receives more blood because it is secreting. It is much more reasonable to assume that it is the change in the tissue brought about by the injurious agent which determines the vascular phenomena. We cannot define how the interaction is brought about, but there are so many examples of the regulation of vascular supply by the demands of the tissue that we must believe in the relation. The dilatation and finally permanent enlargement of a collateral artery after ligature of the main stem is an example; the compensating endarteritis producing a diminution in calibre of a vessel supplying a part which has become atrophied is another example. We can see the vascular phenomena take place under conditions in which injury to vessels can be excluded. In the tail of the tadpole there is a very small margin which is not reached by the vessels and it is possible to cut away a portion of this without touching the vessels, and still the adjacent vessels dilate, the current becomes slow, and an abundant emigration takes place from them. The vessels here have not been injured by the trauma. The same thing is true of central injuries to the cornea. If the centre of the cornea be touched with nitrate of silver a local necrosis of tissue is produced. A brown mass is formed by the precipitation of the silver, but the necrosis extends a short distance beyond the brown eschar. All of the peripheral vessels are affected. There are congestion and abundant fluid and cellular exudation from these, while there may be only slight congestion in the conjunctival vessels above them. It is unreasonable to suppose that these vessels are affected by the extension to them of the action of the silver. How the tissues influence the vessels we do not know. It may be by a purely local nervous mechanism, for the phenomena can be observed in a part in which all connection with the central nervous system has been destroyed. The accumulation of leucocytes in an inflamed part seems to be due not to any change in the vessels but to an attraction for leucocytes which is exerted by the injured tissue. We know that chemical substances have the power of attracting to them micro-organisms which possess independent motion, and leucocytes may also be attracted or repelled by certain substances. The name chemotaxis has been given to this attraction, positive when it attracts, negative when it repels. It is certain that necrotic tissues exert a strong positive chemotaxis for neutrophile leucocytes, and usually wherever an area of necrosis is found leucocytes have invaded it and are in the vicinity. It seems clear, therefore, that to this chemotaxis the presence of the leucocytes in the tissue is due. Substances of chemotactic power may be produced even in the slighter forms of injury in which there is no actual necrosis of tissue produced. Certain of the micro-organisms exert a strong chemotaxis for leucocytes. We are ignorant how these substances exert their action. In the cornea, for instance, are chemical substances produced in the necrotic centre and diffused in the tissue until they reach the vessels; or how do they influence the leucocytes? It is just as possible to explain the emigration of the leucocytes from the vessels in this way as it is to explain their migration in the tissues to the necrotic area. Another thing is very striking. If the cauterization is produced not in the middle but at one side of the cornea the vascular changes and emigration take place from the nearest vessels. No leucocytes will be found in that part of the cornea most remote from the injury. Although it is possible that a chemical substance would reach first and affect with the greatest intensity the vessels which are nearest, it should still exert some effect on the more remote. It can be considered certain that the process of emigration is an active one, the blood cells creeping through the walls by means of amœboid movements. The passage takes place chiefly at the small openings between the cells composing the walls, which in consequence of the dilatation of the vessels are wider than normal. That these openings are wider has been shown by the injection of normal and inflamed vessels with nitrate of silver which stains the intercellular substance. Examination of specimens which show clearly the relation of protoplasm and nucleus shows that the nucleus is in that part of the blood cell which first passes through, following the same law that prevails in migration of leucocytes in the tissues. The adherents of the exclusively vascular theory of inflammation attribute the slowing of the blood stream and the close packing of the cells in the vessels to the alteration of the walls. It is not necessary to assume this. Wharton Jones first pointed out that it could be explained by the concentration of the corpuscles due to the passage of fluid into the tissues. This must increase the friction of the corpuscles in the vessels and at the same time the pressure within the latter is reduced. It is astonishing, in the explanations which have been given of the inflammatory phenomena, how little attention has been paid to the tissues. It is generally assumed that tissue pressure remains the same in all conditions and that the dilatation of the vessels shows a higher pressure on the part of the blood. The process of exudation is active and not a passive filtration under increased pressure. How much it is due to activity on the part of the endothelial cells, analogous to secretory activity, is uncertain. We do not know what changes are produced in the tissue rendering them more capable of taking up fluid from the blood nor how these changes act. We know nothing of the mutual relations of blood and tissue pressure in an inflamed part. It is certain, however, that the tissue pressure is increased; the rapid outflow of lymph from an inflamed part—the greatly increased tension—shows this. It also has been generally assumed that diapedesis is purely mechanical and is due to the red corpuscles being forced through the enlarged spaces in the walls by the increased pressure in the vessels. There can be no question that the process is a mechanical one, but it is much more reasonable to assume that the red corpuscles are carried through the small openings in the vessels by the fluid stream passing into the tissues.

Any injury to the tissues is accompanied by changes in the tissue cells which, taken *in toto*, must be regarded as reparative. In some cases these tissue changes are simple, in others they are extremely complicated. Slight injuries involving only partial loss of surface epithelium are easily repaired by proliferation of the cells adjoining the injured part. This is accompanied by congestion of the vessels and probably by a slightly increased transudation. In more extensive injury involving complicated structures, in which not only cells but intercellular substance must be formed, the changes are more complicated. This may be more easily studied in the cornea than elsewhere. If necrosis is produced in the centre of the cornea by the application of nitrate of silver, changes begin to appear in the corneal corpuscles adjoining the necrosis in the course of a few hours. The first change consists in an increase in the staining capacity of the nucleus due to an increase in the chromatin. The protoplasm also increases in granulation and in amount. The cell processes

become more numerous and are more plainly visible. The new protoplasmic projections are chiefly formed on the side of the cell adjoining the necrosis and extend in long lines into the necrotic territory. The nuclei divide rapidly by mitosis and the newly formed nuclei pass up into the cell process. These become separated from the parent cell and form new corneal corpuscles. Numerous nuclear figures may be seen in the cells eighteen hours after the injury. The proliferation is not confined to those cells immediately adjoining the necrosis, for nuclear figures may be seen in cells several rows distant and in scattered ones in the cornea elsewhere. There seems to be a general increased activity in all the cells of the cornea, for the cells in the entire tissue stain more actively. All the increase in cells takes place by indirect division of the nucleus. In certain of the corneal corpuscles adjoining the necrosis, where the injury was probably not sufficient to produce at once death of the cells, a process of direct division may be observed. This takes place in large swollen vacuolated corpuscles. There is no increase in the chromatin of the nucleus or in the protoplasm which stains rather more faintly. The nucleus becomes vacuolated and the chromatin collects along the periphery in crescentic masses. Constriction and division of both nucleus and cell follow. In the division of the nucleus the chromatin masses at the periphery remain unchanged. There is no increase in the amount of chromatin or in the interchange of its parts. The process is one of cell fragmentation and not of true proliferation. The various steps can be made out only in separate cells. This peculiar form of degeneration is seen more frequently in some cells than in others; it is especially common in the cells of stratified epithelium.

There is no active participation of the leucocytes in regeneration and it may take place without them. In very slight injuries the leucocytes may not reach the affected region; thus, slight necrosis may be produced by touching the cornea with chloride of zinc, yet all emigration may be absent. When leucocytes are present they usually are seen in greatest numbers immediately around the central eschar, where the tissue is filled with the precipitated silver, and when they are among the proliferating corpuscles they are taken up by these. All of the proliferating cells are phagocytic, and their protoplasm contains numbers of polynuclear leucocytes or their fragments. The enclosed cells or their fragments often lie in vacuoles in the protoplasm. Even the connective-tissue cells at a distance, which show increased activity only by the increase of chromatin in the nuclei, are actively phagocytic and take up the fragments of protoplasm which become separated from the travelling leucocytes. In these early stages the process is easily followed and the derivation of the new cells is plainly seen. Later, the new cells become entirely separated from the old and are found in the central area. Here they present little similarity to the old connective-tissue corpuscles. They are round and irregular in shape, the protoplasm is granular and stains easily, the nucleus is more or less irregular in form and contains an increased amount of chromatin. They are usually larger but may closely resemble mononuclear leucocytes. The same process of cell division and phagocytosis may be seen in the mesentery after various forms of injury.

In more complicated tissues, repair or rather tissue change is not so easily interpreted and a variety of cells are affected. In vascular tissues we almost constantly find plasma cells in the late stages of inflammation, even after twenty-four hours. These may or may not be normally present in the tissue. Considerable numbers of them may be found in the subconjunctival tissue around the edge of the cornea. They are not present in the normal mesentery of the rabbit. They are cells varying in size, somewhat larger than polynuclear leucocytes, with an abundant granular protoplasm which is stained with almost all reagents, but particularly with polychrome methylene blue. The nucleus is round or oval with abundant and brightly stained chromatin arranged peripherally. Larger cells may be seen containing two or more nuclei but otherwise of the same character as the smaller. There is much uncertainty about the origin of these cells. They more closely resemble the lymphoid cells than any others and apparent transitións may be seen between them, the protoplasm and the chromatin of the lymphoid cell increasing in amount and staining more actively. They are amœboid and may be found in the corneal spaces a considerable distance from the periphery. I am strongly of the opinion that they are derived from the lymphoid cells. Others believe that they are produced from the fixed cells of the tissue and take part in tissue formation. They are never phagocytic, but like the lymphoid cells they are taken up by other cells. In some cases they are certainly brought to the part by the blood and pass by emigration from the blood-vessels into the tissue. In the kidney I have seen them in the act of migration. It has not seemed to me that they take any part in tissue formation. They are most numerous in the chronic inflammations in which injury and repair are going on continuously. Nuclear figures are numerous in them and they certainly increase in number in this way. The lymphoid cells take no part in tissue formation. With regard to the large mononuclear leucocytes there is more doubt. It is certain that their presence in the inflamed part is due in part to emigration from the vessels. It is not certain whether this is their only source. I am disposed to regard these cells as endothelial in origin and they may be formed in the part from the endothelium of blood-vessels or other endothelium. It is difficult to differentiate them from young tissue cells. It is not probable that they take any part in tissue formation, but in the difficulty of distinguishing them from cells which certainly are tissue producers it does not seem possible to decide. In the regeneration of the destroyed tissue intercellular substance as well as cells must be formed. Fibrillæ are formed between the cells early. The newly formed intercellular substance may contain elastic fibres and the ordinary fibrillæ of white fibrous tissue. It is generally believed that the fibres are differentiated from an intercellular substance produced by the cells and not formed in them. When the tissue has been entirely destroyed the newly formed connective tissue is not of the same quality as the old. The fibrillæ are thicker and tend to adhere together, forming thick masses, and the tissue is more opaque and may be recognized long afterward as the cicatrix which remains.

The activity of regeneration depends upon the character of the agent which produces the injury. While it begins early and is active in the cornea after simple injuries, there may be no evidence of it twenty-four hours after inoculation with staphylococci. Of course there can be no laws governing the reaction of the tissues to other bacteria, for some of them may directly excite the tissue cells to proliferation.

Tissue proliferation of any extent is accompanied by formative activity in the blood-vessels belonging to the part, leading to a new formation of vessels. (Plate XXXV., Fig. 3.) No better place than the cornea can be selected for the study of this process. Evidences of this formative activity are seen first in a general increase in size and staining capacity of the endothelial cells. The large cells proliferate and form new vessels. The new vessel begins as a process from one of the endothelial cells which projects into the tissue, the process coming from a cell on the side of the vessel toward the injured area. The process enlarges, nuclei are formed by mitotic division and pass into the process, and new cells may be formed from the adjoining endothelium. The process of cells becomes hollow and communicates with the lumen of the vessel from which it arises. The process is pointed at the end and often several points are given off from it. Some of these processes unite with similar processes from other vessels, a loop is formed, and the circulation is thus established. Great numbers of these vascular processes arise, though but few of them form true vessels. It is uncertain whether the growing ends exert a positive attraction for each other or whether the junction is fortuitous. It is possible that the cell spaces of the tissue

have an influence in determining the direction of the growth. In the cornea I have found that new cells may line such a cell space which then becomes a part of the lumen of the new vessel. It is not probable that tissue cells are formed from the vascular cells. The new blood-vessels persist as long as the active cell proliferation is continuing. They finally atrophy and a cornea which showed a marked pannus may again become perfectly clear. The new blood-vessels are formed from that part of the periphery which is nearest to the injury.

The processes of repair are different in the different sorts of tissue. The repair is most perfect and simplest in character in tissues which are least differentiated and homogeneous. This is easily seen in sections passing through the skin and subcutaneous tissues. Laparotomy incisions have supplied us with an abundance of material in man illustrating every stage of inflammation and healing in different tissues. The process can also be studied experimentally by incisions into the rabbit's ear. In incisions of the skin there is less inflammation in the connective tissue than elsewhere. If the wound is not infected and the coaptation of the edges is perfect, healing may take place with almost an absence of leucocytes. New cells are formed from the connective-tissue corpuscles nearest the incision, and permanent union is first effected by the interlacing of the processes of these cells. Here also as in the cornea the cell proliferation is much more extensive than would be required solely for the purpose of regeneration. Nuclear figures may be met with in the tissues at quite a distance from the line of incision and injury. When the section in the rabbit's ear passes through the cartilage no regeneration takes place in this. The portion of cartilage immediately adjoining the incision degenerates and the nuclei break up into nuclear detritus. The ends of the cartilage become included in the connective tissue formed around them, and permanent union takes place by the metaplasia of the connective tissue, the cells becoming transformed into cartilage cells and the fibrillar tissue into the homogeneous matrix. Where the laparotomy wound passes through the subcutaneous fat, healing takes place only after this has been removed. This is accomplished by the presence of large phagocytic cells which appear around the fat droplets. The origin of these cells is uncertain. They suggest in their general characters endothelial cells. By these cells the fat is removed and connective tissue appears in its place. This fat absorption takes place at a considerable distance from the line of incision, and usually numbers of leucocytes are found in the tissues. The large cells are found in injured tissue which contains fat, and they are very numerous around necrotic areas in the central nervous system. The incision through the muscle leads to extensive necrosis which involves the muscle on either side for a considerable distance from the line of incision. The necrotic fibres are invaded first by leucocytes and then by large cells, probably of endothelial origin, by which the necrotic tissues are removed. There is very extensive proliferation of the nuclei of the sarcolemma which seems to take place by direct division and to be degenerative in character. Long rows of vesicular nuclei containing but little chromatin are found in the ends of the fibres and extending some distance along them. I have never found any nuclear figures or evidence of true division here.

The fluid exudation finds its way out of the tissues in various ways. A purulent exudation may produce gradual softening of the overlying tissue and thus provide a way for its discharge. In parts with such a thin covering over them as exists in the alveoli of the lung the exudation easily passes through to the surface. Even when the surface is a mucous membrane the exudation may readily find its way between the cells. The abundant discharge from an inflamed mucous membrane is principally composed of the exudation coming from the tissue beneath, but is mingled with an increased secretion from the mucous glands. The greater portion of the exudation is removed by the lymphatics. It has long been known that the lymphatics coming from an inflamed part are dilated and the flow of lymph is increased. This flow is proportional to the amount of fluid exudation in the part, but it may not be proportional to the amount of tension and swelling in the part, for this may be due to the presence, in the exudation, of material like fibrin which will not pass away by the lymphatics. On microscopic examination the lymphatics in a tissue adjoining an inflamed part are found to be dilated and easily recognizable. It is remarkable that they contain so few cells. The cells of the exudation are not removed, to any extent at least, by the lymphatics. The lymphatics contain an abundant granular coagulum and usually a small bunch of cells, among which may be a few red corpuscles and degenerated leucocytes which probably came from the exudation; but most of the cells within them are cells of endothelial character probably derived from proliferation of the lining cells. This seems to be true of the lymphatics in all tissues of the body and in various forms of inflammation. I have studied carefully the lymphatics of the lungs in various forms of pneumonia. They are dilated, they contain granular coagulum and often considerable fibrin, but they contain few or no cells from the exudation. It does not seem to me probable that any of the exudation cells return to the blood from the tissues either directly from the blood-vessels or indirectly by means of the lymphatics. No one has seen the emigration from the tissues into the blood-vessels in the living tissues nor can any evidence of it be seen in the hardened tissues. It is difficult to see, unless we attribute to them an independent volition, what influence could be exerted on the exudation cells to induce their return. Some of them are devoured by phagocytes, and they undoubtedly contribute in this way to the building up of the tissues, but the great mass of them is probably dissolved or digested by the tissue fluids.

A fibrinous exudation on a surface is removed by the process of organization. In this a highly vascularized tissue grows up into the fibrin and gradually removes and replaces it. How the removal is brought about is uncertain. The fibrin simply disappears before the growing tissue, becoming first more homogeneous and then hyaline. In the last stage of the process irregular, swollen, hyaline masses of fibrin are found on the surface and within the new connective tissue.

Before our recent knowledge of the formation of leucocytes and the conditions under which it takes place there was much uncertainty as to the origin of the great numbers of leucocytes found in an inflamed part. It could not be explained without the assumption of some increase in the number of leucocytes, for those found in the exudation in croupous pneumonia might exceed in number the leucocytes ordinarily contained in the entire mass of the blood. It has been found from blood examinations that in inflammation there is an increase in the number of leucocytes in the blood. In croupous pneumonia there may be eight times the normal number of leucocytes, the increase being only in the neutrophiles. The relation of leucocytosis to inflammation has recently been studied by Brinckerhoff in the rabbit. He has found that in the beginning of the exudation leucocytes are withdrawn from the blood more rapidly than they can be replaced and a condition of hypoleucocytosis is produced. This is but temporary and the number in the blood rapidly increases to the normal and beyond. Examination of the bone marrow at corresponding periods shows that in the beginning of the increase in the blood the amphophiles stored in the marrow rapidly leave it, producing a local hypoleucocytosis which is followed by a rapid new formation of amphophiles. The blood examination gives us a further proof that there is no return of the leucocytes into the blood. In pneumonia the number of leucocytes in the blood rapidly falls at the crisis and may reach the normal at the time when there is the most rapid absorption of the exudation. If the leucocytes did return into the blood there should be an increase at this time.

The forms of inflammation which we have considered so far may be termed acute. They were excited by an agent which produced an injury to the tissue and whose

EXPLANATION OF
PLATE XXXV.

EXPLANATION OF PLATE XXXV.

FIG. 1.—Muscle in Vicinity of Necrosis Produced by Croton Oil, Showing Absorption of Necrotic Muscle Fibres and Proliferation of Tissue Cells. 4 mm. Zeiss.

FIG. 2.—Single Muscle Fibre Undergoing Absorption by Endothelial Cells. The dark masses represent the remains of the necrotic tissue. All the fissures in it are filled by the protoplasm of the phagocytes. One-twelfth hom. immersion, Zeiss.

FIG. 3.—New Blood-Vessels Extending into Cornea from Scleral Margin Three Days after Inflammation Produced by Inoculation with Staphylococcus Aureus. 8 mm. Zeiss.

FIG. 4.—Granulation Tissue Showing Newly Formed Blood-Vessel from which Emigration is Taking Place. 4 mm. Zeiss.

FIG. 5.—Edge of Muscle Showing Ingrowth of Connective Tissue Five Days after Inflammation Produced by the Application of Croton Oil. 8 mm. Zeiss.

FIG. I.

FIG. 2.

FIG. 3.

FIG. 4.

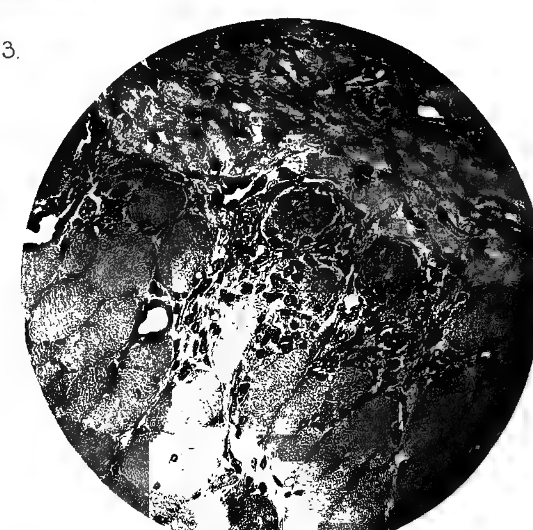

FIG. 5.

CHRONIC INFLAMMATION

action ceased with the production of this injury. The tissue changes were the result rather of the injury produced by the agent than of the agent itself. It is possible in various ways to excite an inflammation in which all the phenomena which have been seen in acute inflammation develop much more slowly, or some of them may be entirely wanting, the whole process lasting much longer or even indefinitely. Such inflammations are termed chronic. It is of course impossible to assign any limits to the acute inflammations, and we cannot say that after so many days an inflammation ceases to be acute. The terms acute and chronic, therefore, while convenient, are difficult of definition. Chronic inflammations may be produced, first by the continuous action of an injurious agent, secondly by the repeated action of slight causes on a tissue which is not normal and not capable of resisting this action. In chronic inflammation, again, the changes in the tissue are marked and exceed in importance the exudation. The best types of chronic inflammation are seen in the inflammations around foreign bodies and in the ulcer. Inflammation surrounding foreign bodies may be studied by the introduction of various foreign bodies into the tissues of rabbits, and by the accidental material which is provided by surgery. Silk suture may remain in the tissues an indefinite time without undergoing absorption. The changes which take place are of two sorts: first, those which have for their object the absorption of the material (Plate XXXV., Figs. 1, 2); second, those which lead to the formation of an indefinite tissue which can resist the action of the foreign substance. Sections made across a silk suture which has been introduced into the muscles of the leg of a rabbit show in twenty-four hours around the suture an area of necrotic muscle. If the suture has been soaked in corrosive sublimate the fibres immediately adjoining it show no change. They have been killed by the corrosive and preserved in their normal state in the same way as muscle is hardened in a preservative. Such muscle fibres resist invasion by phagocytes. Farther out is an area where the nuclei of the fibres have disappeared and the fibres are swollen and hyaline. There is an abundant exudation of leucocytes which infiltrate the necrotic muscle and the suture. There is a slight new formation of cells in the surrounding tissue and the ordinary nuclear increase in the muscle nuclei. Sections made at late periods show first the degeneration and final disappearance of the leucocytes and the necrotic muscle fibres. The necrotic fibres are invaded by leucocytes, but it has not seemed to me that these are the true phagocytes. The final removal is effected by cells of the endothelial type (Plate XXXV., Figs. 1, 2) for which the way has been prepared by the leucocytes. The leucocytes all degenerate. The place of the exudation cells and necrotic tissue is taken by a tissue composed for the most part of spindle or irregularly shaped cells with large nuclei. Around the silk fibrils there are large protoplasmic masses containing a number of nuclei. These may surround the fibrils, and on longitudinal section are found to extend along them a considerable distance. These giant cells are formed from the cells of the tissue. They may be produced by coalescence of cells, or by the increase in size of a single cell with proliferation of nuclei but without succeeding division of protoplasm. They are formed about foreign bodies of all sorts. In wounds of the skin they are found with enclosed masses of connective tissue and elastic fibres. The silk fibres enclosed within them undergo no change even in the course of years. Sections made several weeks after introduction of the suture show that nearly all of the newly formed tissue has disappeared and the suture is surrounded by a thin mass of connective tissue, but which extends for some distance between the fibres of the surrounding muscle. The amount of the newly formed connective tissue varies greatly in different cases and according to the character of the material used for suture. It is very much greater around catgut than around silk suture. The catgut suture may remain unchanged in the tissue for a considerable time. It appears on section as a dense homogeneous mass surrounded by leucocytes, and later by newly formed tissue. Leucocytes do not invade it until cracks and fissures are formed in it. It appears rather to undergo slow softening and dissolution in the tissue than to be removed by phagocytes.

In the ulcer there is a combination of conditions. There is a constant trauma acting on the surface which has been deprived of its protective covering. The surface of a skin ulcer is always covered with a thin layer of necrotic tissue, within and below which there is an abundant infiltration with leucocytes. Extending to a variable depth below the surface there is a tissue composed of newly formed blood-vessels and of young connective tissue rich in cells. Between the cells of the connective tissue there are a few connective-tissue fibrillæ. The whole tissue is loose and œdematous, it contains great numbers of lymphoid and plasma cells, principally in groups around the vessels. The newly formed blood-vessels are large (Plate XXXV., Fig. 4), their walls are composed of large endothelial cells, with large nuclei, projecting into the lumen, and from them there is abundant emigration. This tissue remains until the surface is covered with a regenerating epithelium, and is finally replaced by dense connective tissue containing few cells or vessels. Such a tissue is made less resistant to traumatic influences than is normal tissue. In the first place it probably receives more injury from a blow or from pressure owing to its density and consequent inability to distribute the influences of the trauma. The blood-vessels in it are few in number and owing to the density of the tissue are less capable of quick dilatation and the increased nutrition necessary for repair. This condition is always to be considered in chronic inflammation. The repair of a tissue after an injury involving destruction of complicated structure is never perfect. Repair involving cells alone easily takes place and is perfect, but the tissues seem to have lost the power of forming again tissue of the same character as that produced in the embryonic condition. Chronic inflammation is frequently the result of repeated separate injuries produced by influences which come within the normal, acting on a tissue whose capacity for resistance and repair is low and which is continually lowered by each succeeding attack.

Healing of the abscess may take place in a number of ways. The exudation and with it most of the infectious agents which have been produced may be removed in the ways we have spoken of. There remains a surface which is very similar to the surface of an ulcer. It is infiltrated with leucocytes and contains numerous vessels and young tissue cells. The bacteria are partly removed, many of them are enclosed in phagocytic cells, the tissue has become resistant to the action of those that remain, and thus a local immunity is produced. The cavity becomes obliterated by the contraction of the tissue and the growing together of the walls.

It would be impossible within the limits of this article to consider further the special forms of inflammation due to the character of the tissue or the nature of the injurious agent. In certain organs the processes of inflammation may differ in a marked degree. In the kidney, for instance, there are lesions which come under the broad interpretation of inflammation which are not found in any other situation. In general, however, all the differences which are met with are but variations of the processes which have been described. *W. T. Councilman.*

INFLUENZA.—*Influenza* is an acute, self-limited, infectious fever, occurring in widely distributed epidemics, and characterized by catarrhal inflammation of the respiratory and gastro-intestinal mucosa, by profound nervous disturbances, and by extreme debility.

Synonyms: Febris catarrhalis; Epidemic catarrhal Fever; La Grippe; Grip; Tac; Horion; *La Dando; Ziep; Epidemischer Husten; Epidemischer Schnupfen; Schafhusten; Blitz-Catarrh; Mödefieber; Mal Russe; Snufsjuka* (Swedish); *Qual-Tong* (Chinese).

Many other synonyms, grave and humorous, might be listed which have been suggested by the peculiarities of various epidemics, the national characteristics of the

people affected, or some fancied resemblance of the symptoms, but *influenza*, *la grippe*, or the Anglicized *grip*, have practically superseded all other names, in medical as well as lay circles.

Influenza is of Italian origin, and was probably first employed by the Italian savants to indicate the supposed occult influence of the stars over the course of the disease. Wolff states that it was first used by an Italian author, Gagliardi: "Parere sopra l'Influenza catarrale, che presentamente regna in Roma e stato ecclesiastico, Roma, 1733."

Other authorities, however, trace its origin to the English writers Pringle and Huxham, the latter of whom, in describing the epidemic of 1742-43, writes: "Quæ per totam Europam hoc vere sub nomine influenza grassata est."

The derivation of *la grippe* is likewise in doubt. Most authors refer its origin, and probably correctly, to the French, *agripper*, to seize, but others derive it from the Polish, *chrypka*, or *grypka*, hoarse. It came into general use in France during the epidemic of 1732 (Marigné: Description et traitement d'une affection catarrhale epidémique observée en 1732, vulgairement appellée la Grippe, 1776).

Historical Sketch.—Since the appearance of the fourth volume (1887) of this Reference Handbook, containing the brief article on *Influenza*, a series of epidemics has swept over the world, which, for rapidity of movement, extent of distribution, and numbers affected, rival all previous visitations of the disease. This series, which began in the fall of 1889, was the first general epidemic of la grippe since 1847-48, and really introduced the present generation of practitioners to a disease known to them only in history, and thus became one of the notable medical events of the latter half of the nineteenth century.

Recurring at a time when the study of the infectious diseases was being pushed so zealously along bacteriological lines, and engaging in its study the ablest clinicians of every nation, it was confidently predicted that the mysterious problem of its nature and etiology would be speedily solved. While this prediction has not been thoroughly fulfilled, our knowledge of epidemic influenza has been materially increased and necessitates a restatement here.

In this necessarily brief historical sketch we shall not attempt a complete chronological account of the epidemics of all ages, but shall allude only to those which, from special incidents, mark an era in the progress of our knowledge, and endeavor to trace somewhat in detail the course of the recent epidemics of 1889-92.

Medical historians have interpreted the vague utterances of Hippocrates and Livy, referring to a disease which assumed epidemic proportions in 412 B.C., as the first written allusion to influenza.

Mention is made of an epidemic which prevailed extensively in the latter part of the sixth century, in which the prominent symptoms were headache, debility, cough, and an irresistible desire to yawn. Sneezing was usually the first symptom of the prevailing distemper, and the custom of calling down "God's blessing" upon one who was heard to sneeze is said to have originated at this time.

It is very probable, as maintained by many authors, that not a few of the general epidemics described in the earlier medical chronicles under various names (catarrhal fever, Italian fever, etc.) were epidemics of true influenza.

Parkes traces the disease back to the ninth century. In 827 and 876 epidemics in which cough was the most prominent symptom, and which also extended to domestic animals and birds, originated in Italy and spread rapidly over all Europe. The epidemic of 876 is said to have sadly discomfited the victorious army of Charlemagne on its return march from Italy.

But one epidemic, and that limited to Germany and France, is known to have occurred in the tenth century, after which the world apparently enjoyed immunity for about two hundred years.

Whatever may have been the nature of these early epidemics, our positive knowledge of influenza, according to Wilson, dates from the great visitation of 1510, which covered the whole of Europe and the British Islands, and was so general that "not a single family and scarce a person escaped it."

The epidemic of 1557, which appeared suddenly in Eastern Asia and spread rapidly to the West, was the first influenza epidemic which is known to have crossed the Atlantic to America. This pandemic was very severe in certain localities and was attended with a high mortality. Five thousand are said to have died in Delft alone within a short period.

During the past four hundred years there have been about seventy epidemics of grippe, one-half of which, from their widespread prevalence, deserve to be called pandemics.

The century just closed had thirteen visitations; the last important one previous to 1889 was that of 1847, in which were stricken more than one-quarter the population of London and Geneva, and fully one-half that of Paris.

The course of the later epidemics has been quite uniformly from east to west. It is, of course, only the general trend of the epidemic that can be followed, since every locality invaded becomes at once a new centre from which arms of infection reach out in every direction. With few exceptions, the later pandemics of influenza originated in Eastern Asia, where the disease may almost be said to be endemic. From this nidus they travelled westward across Russia, thence over continental Europe and the British Isles, over the ocean to America, Australia, East Indies, until, like Puck's girdle, they circled the globe.

The epidemic of 1889-90 followed closely the beaten path. The first cases of which we have knowledge occurred in Bokhara, Central Asia, in May, 1889. The disease became quite prevalent in July, and following the lines of the new railways slowly invaded other portions of the Russian empire.

The epidemic can be easily traced through Western Siberia and the post-towns and stations in Russia in its march toward St. Petersburg, which was reached by the end of October, and two weeks later it had assumed such startling proportions in that city as to attract the attention of the civilized world.

From St. Petersburg the epidemic spread with unprecedented rapidity, and the cities of Western Russia, Central and Northern Germany, Austria, France, and the British Islands became, in turn, the scene of its ravages, until by the end of December it had compassed the whole of Europe. Scattering cases announced the appearance of the disease in New York about the middle of December, and a week later it had assumed epidemic proportions. From the seaboard it extended in every direction, and during January, 1890, was generally diffused over the United States, British North America, the Sandwich Islands, and Central America (Guatemala).

From its starting-point in Central Asia the epidemic also extended in a southeasterly direction. Malta, Cyprus, and Egypt were successively visited in January and February. It was reported from India in February, became epidemic in March, and prevailed extensively in Upper and Lower Burmah during April and May. It reached Arabia in April, many of the pilgrims arriving from India and the Straits having sickened on the voyage.

In the Southern hemisphere the course was from the south northward. Cape Town was the seat of its first appearance in Africa, it having been carried thither by steamers; thence it extended northward, reaching Mauritius in August, the Shire Highlands in September, and Abyssinia in November, 1890.

South America was reached in February. Buenos Ayres was infected presumably by steamer from Bordeaux; thence it travelled up both coasts and prevailed in Brazil, Chili, and other states during April and May. It was notably severe in the province of Pernambuco. It

was prevalent in Australia and New Zealand from March to July.

In Iceland it occurred in July, and in some remote places of China and Kashmere during September and December.

Dr. Parsons, in his exhaustive report to the British Medical Association, July, 1891, to which we are largely indebted for the facts above related, writes: "Thus assuming the epidemic to have started from Russia in October, it took about six weeks or two months to spread over Europe and reach North America, rather more than two months to reach the Cape, three months to reach South America, four months to reach India, five months to reach New Zealand and Australia, nine months to reach Iceland, ten months to reach Mauritius, and nearly a year to make some remote places in Africa and Asia."

During the summer and fall of 1890 influenza was "smouldering on," as shown by the numerous local outbreaks, usually of short duration, in different parts of the world.

The second general epidemic—1891—began in January, and was but little less extensive, and probably more fatal, than the one just sketched. It, too, was pandemic, but in the journey around the world the course of its predecessor was reversed, and the general trend was from west to east.

The origin of the epidemic is traced to New Orleans, where influenza prevailed extensively and fatally in January, and from which it radiated in every direction. During February, March, and April it spread over the Northern States and was notably severe in Pittsburg and Chicago (March) and the seaboard (April). It was reported from England in April, from Germany in August, from Scandinavia and Denmark in July, from Russia (St. Petersburg) in September, from France in October, from Italy in December, and thus passed from country to country until almost the whole civilized world had been revisited. This epidemic also ran its course in about one year.

Since 1889 each winter has brought a recurrence of epidemic influenza, varying in extent and severity, to all parts of the world. Few American cities have escaped an annual visitation.

Nature and Etiology.—It has been customary to regard influenza as an epidemic catarrhal fever, but recent *dénouements* have materially strengthened the belief, long entertained by some, that it is really an infectious nervous fever.

Many of the symptoms are most readily explicable upon a neural basis, while its bacterial origin, together with the knowledge of the toxæmias that usually attend upon bacterial infection, gives support to such an explanation. Much testimony has accumulated during the recent epidemics to show that the nervous symptoms are primary and are followed by secondary involvement of the respiratory and digestive organs. In a given case the pulmonary, gastro-intestinal, or cerebro-spinal symptoms predominate as the nervous apparatus of one or the other system bears the brunt of the disease.

Nervous symptoms are uniformly present and usually pronounced, even in the mildest forms of grippe, while, on the other hand, in many of the worst cases, catarrh of the mucous membranes and inflammation of the respiratory tract are totally absent.

Again, when catarrh and pneumonia are present, they frequently assume "such a peculiar character as to lead to the suspicion that they might arise from irritation of, or loss of power in, the various nervous mechanisms supplying the affected parts, and would therefore have to be looked upon more as vaso-motor and trophic neuroses than as ordinary catarrh and inflammation."

The histories of the various epidemics prove clearly that the disease is not dependent upon climate, soil, season, meteorological or electrical conditions. It affects all classes of people, irrespective of nationality, sex, social position, or environment, although infants and young children seem to possess partial immunity. While no season of the year is exempt, late autumn and early winter are the periods of its greatest frequency.

The phenomena of influenza are comprehensible only upon the theory of a specific infecting virus or germ as the exciting cause. Its epidemic occurrence, transmission along lines of travel, rapid diffusion, sweeping over whole continents in a few weeks, and affecting nearly the entire population in a certain district in a few hours after its appearance, indicate some powerful morbific agent in the atmosphere which acts specifically upon the animal economy.

A few authors still cling to the theory that the morbific agent is a miasmatic material; but the generally accepted doctrine, and the one most in accord with our knowledge of the etiology of infectious diseases, is that which makes it dependent upon the presence of a microorganism.

For long the pathogenic bacillus eluded the vigilant search of bacteriologists, although from time to time its discovery was prematurely announced. Thus Weichselbaum's lancet-shaped diplococcus, Klebs' flagellatum, Jelly's hassock-shaped coccus, Kirchner's punctiform microbe, and Babes' radiated bacterium, each in turn failed in the crucial test and was relegated to obscurity along with Saulsbury's infusoria and Seifert's micrococci.

At the time of the last revision of this article (1893) Richard Pfeiffer had just announced the discovery of an organism which he regarded as the specific exciting agent of influenza.

This conclusion has been confirmed by later observers and is now universally accepted, although positive proof by the experimental reproduction of the typical disease has not yet been satisfactorily obtained.

Pfeiffer's bacillus is a tiny rodlet 0.8 to 1 μ long and 0.1 to 0.2 μ broad, about the same thickness and half the length of the bacillus of mouse septicæmia. It is the smallest bacillus yet isolated, and in cultures is recognizable during the first twenty-four hours only by means of a lens, so that macroscopically a test tube containing them can scarcely be distinguished from a sterile one. They are, however, readily differentiated by the peculiarity of their growth, as the colonies always remain separate and do not, like the colonies of other bacteria, join together and form continuous rows. When neighboring colonies come together the contours of the several colonies remain recognizable. Under the microscope they show a peculiar glassy transparency and are almost structureless.

The influenza bacilli are stained with difficulty. They respond either to a dilute Ziehl-Neelsen solution of carbol fuchsin or to a hot Löffler methylene-blue solution but do not react to Gram's stain.

The bacilli have been found in large numbers in sputum, bronchial, pleural and pneumonic exudations, and in the blood (Canon). They are present in such enormous numbers in the sputum of influenza patients that the bacteriological diagnosis is ordinarily a simple problem.

Inoculation experiments have been negative in most species of laboratory animals (mice, guinea-pigs, pigeons, etc.), but Cantani has recently succeeded in producing in rabbits a fatal form of influenza with profound nervous symptoms, by the intracerebral injection of living bacteria. And, contrary to the usual result of inoculations, the specific bacteria were found increased not only at the local seat of infection but also in the circulating blood and in remote organs.

It is highly probable that the action of the morbific principle of grippe is not limited to man. Epizoötics, very similar in many respects to the epidemics in the human race, have often prevailed among domesticated and wild animals, especially horses, dogs, and cats.

The attention of the profession was first called to this fact by Huxham in connection with the epidemics of 1732–33. These epizoötics occur independently, but more often happen either simultaneously with or immediately precede or follow epidemics of influenza. Bartholow favors the view that the epidemic disease in ani-

mals is the parent of that in man, but is so modified by transition that each succeeding epidemic is milder and less aggressive.

The contagiousness of influenza has long been a mooted question. The fact that inoculations thus far have been unsuccessful in transmitting the disease still remains the strongest argument for the negative side of the proposition. The doctrine that contagion is the most important if not the only method of its propagation has, however, been strengthened by numerous observations made during the recent epidemics and is now accepted by most clinicians.

The frequency with which epidemics, both in their general and in their local distributions, follow the regular lines of travel, the immunity of isolated households and communities, and the frequency with which local outbreaks have been traced to their sources leave, indeed, little room for scepticism. It has been abundantly proved that the spread of influenza is not materially affected by the direction of the prevailing winds; and, in fact, some recorded observations indicate that it may even travel more rapidly against than with the wind. The marvelous rapidity with which influenza sometimes spreads in a community once infected is readily accounted for by its remarkably short period of incubation. It is claimed by many that personal contact with infected individuals or materials is the only method of its propagation. The supporters of this doctrine contend that the dissemination of disease germs through the air must have its limitations. That they can be carried thousands of miles in air currents without dispersion or destruction, or the assumption, on the other hand, of a proliferation in the air itself, does violence to our knowledge of the life history of disease germs. There are, however, too many irregularities in the behavior of grippe epidemics, not necessary to be enumerated here, to permit us to accept personal contact as the only factor in its propagation. Hirsch has pointed out that notwithstanding the modern facilities of intercommunication and rapid transit, epidemics do not travel more rapidly now than under the old régime.

The passengers and crews of ships which have sailed from non-infected ports, and have held no communication with other ships, have been repeatedly attacked in mid-ocean.

The following striking instance is related by Sir Thomas Watson: The frigate *Stag* anchored at Berry Head, on the Devonshire coast, all on board well, April 3d, 1833, the very day on which Watson saw his first cases of influenza in London. The breeze was off the land, and in half an hour after dropping anchor forty men were down with influenza; six hours later the number was increased to sixty, and soon reached one hundred and sixty.

The period of incubation is very variable, both in individual cases and in different epidemics. It may develop almost immediately after exposure, from which it has received one of its popular names, *Lightning Catarrh, Blitz-Catarrh;* but in other instances there is an incubation period lasting from a few hours to several days.

Dr. Goodhart has recorded some startling instances of the suddenness with which strong men engaged in their ordinary vocations were stricken with the disease.

Influenza is no respecter of sex or age, though males between the ages of twenty and fifty years seem most susceptible to the infection.

One attack does not confer immunity from subsequent ones, and a few persons even experience a second seizure during the same epidemic. An epidemic, as a rule, lasts from four to eight weeks in a given locality, although many run a shorter course and often end as suddenly as they began. The rate of progress varies greatly, not only in different epidemics but also in the same epidemic as it spreads over different districts.

There is no causative relation between influenza and other epidemic or infectious diseases. The statement that prevalent infectious diseases abate in frequency and intensity upon the appearance of grippe is not sustained by facts. Neither is there any ground for the popular belief that cholera follows in the wake of influenza. In some instances, notably in 1831, 1847, and 1856, the two diseases have been closely associated in point of time, but the official report of the French commission fully indorses the conclusion of Gluge and Smolensky that the association was purely accidental.

Morbid Anatomy.—The anatomical lesions found after death give meagre information as to the pathology of influenza. A fatal termination is almost invariably due to complications, and the structural changes found post mortem are characteristic of the secondary disease, and not of influenza. Death rarely occurs in uncomplicated cases. The lesions peculiar to influenza are almost exclusively localized upon the respiratory mucous membrane. The mucous lining of the larynx, trachea, and bronchial tubes is hyperæmic, swollen, and covered with frothy or viscid muco-pus. The catarrh may extend to the finer bronchi, but is ordinarily limited to the trachea and larger tubes. The bronchial glands are sometimes enlarged and softened. The gastric and intestinal mucous membrane is more or less congested in a considerable portion of the cases. The solitary and agminate glands of the intestine are not usually implicated.

Kernig, of St. Petersburg, found the spleen enlarged in all cases which came under his care.

Symptoms.—The complexus of symptoms of influenza is exceedingly varied, and this variability extends not only to different epidemics, but also to individual cases of the same epidemic. In many cases the attack closely resembles an ordinary catarrh, with little fever and slight hyperæmia of the naso-pharyngeal mucosa; again, it assumes the form of an intense infectious fever, with profound involvement of the nervous centres, while between these extremes are found cases of almost every grade of severity, and almost every combination of symptoms.

Many attempts have been made satisfactorily to classify the protean forms of the disease. The classification most generally followed by recent writers, one which is a modification of that long ago proposed by Hufeland, is into:

1. The nervous form.
2. The catarrhal or respiratory form.
3. The gastro-intestinal form.

It is estimated that in the recent epidemics about fifty-five per cent. of the cases belong to the nervous, thirty per cent. to the catarrhal, and fifteen per cent. to the gastro-intestinal form of the disease. These estimates will undoubtedly have to be changed for different localities. According to the observation of the writer, nervous symptoms predominated in about eighty-five per cent. of the cases in the epidemic of 1889–90, while in that of 1891 the catarrhal and gastric forms were more common and severe, but still constituted a small percentage of the cases. The division is, however, purely arbitrary, and finds its chief value in emphasizing the fact that the brunt of the attack may fall upon any one of the three great systems.

Influenza usually begins abruptly, but is occasionally preceded by a feeling of indisposition or malaise of from a few hours' to several days' duration. A distinct chill, or, oftener, a mere chilliness, is at once followed by a rise of temperature and the symptoms of a naso-pharyngeal catarrh, with cough, sore throat, frontal headache, pains in and general soreness of the limbs, depression of spirits, and sometimes with gastro-intestinal disturbances.

The fever is remittent in type, variable in intensity, rarely exceeds 104° F. in uncomplicated cases, and subsides by lysis, rather than by crisis. As a rule, the temperature reaches its maximum at the beginning or early in the attack, and often drops below normal during convalescence.

A subnormal temperature has also been noted by many during the progress of the disease, accompanied usually by surface coldness, feeble circulation, and other evi-

dences of depression. The later epidemics were peculiar in the large number of cases in which the fever took on a continuous type, and persisted for two or three weeks, resembling in many of its features a mild typhoid fever.

Anomalous cases were also recorded in which the whole course of the disease was afebrile, and, according to Eichhorst, these were particularly liable to nervous explosions.

The pulse is moderately increased in frequency and changeable in rhythm and quality. The tendency to cardiac asthenia, so pronounced in grave cases, often becomes a serious menace in those of moderate severity. An extraordinary slowing of the pulse is sometimes observed. The pulse may register only in the forties or fifties and naturally excites fears of some cerebral complication. This abnormal retardation belongs to the natural history of the disease, although it is often erroneously attributed to remedies, especially if digitalis or other cardiac sedatives have been administered.

Coincidently with the fever, and sometimes preceding it, the symptoms of an acute catarrh of the upper air passages are manifested.

There are frequent paroxysms of sneezing, a feeling of stuffiness in the head, the eyes are suffused and watery, and coryza with an abundant secretion of mucus speedily follows. The mucous membrane of the nose, mouth, frontal sinus, pharynx, and larynx is congested. The voice becomes hoarse or reduced to a whisper. Cough is rarely absent, usually severe, and recurs in paroxysms which harass the patient day and night. At first it is harsh and brassy and attended with a scanty muco-serous expectoration, which, as the disease progresses, becomes abundant, muco-purulent, and often blood-streaked.

Sharp pains in the sides and under the sternum, dyspnœa, and suffocative paroxysms are experienced, and, as was long ago pointed out by Graves, of Dublin, often without any recognizable intrathoracic lesion. The catarrhal process does not, as a rule, extend below the larynx or trachea, but if it should invade the lower air passages, the deepening of the symptoms at once announces the fact and the illness assumes a more serious aspect.

Nervous symptoms are uniformly present, but vary greatly in intensity. In some epidemics, notably in 1889–90, they predominated over all other symptoms. Severe headache, usually frontal, and pain in the eyeballs are rarely absent. The head pain comes on suddenly, is nearly continuous, dull, and throbbing, with frequently recurring paroxysms of atrocious severity. It is exaggerated by pressure or movement, and is often associated with hyperæsthesia of the scalp and neck.

With the headache there is stiffness and soreness over the entire body, as if it had been beaten, and a backache which in its intensity is suggestive of dengue or smallpox.

The patient either lies perfectly quiet, to prevent the suffering which the slightest movement causes, or tosses restlessly about in the futile effort to find a position of comfort. Sharp neuralgic pains dart along the principal nerve trunks, but show a decided preference for the trigeminal, intercostal, lumbo-abdominal, and sciatic nerves. These neuralgias are often intermittent, but do not exhibit the periodicity of ordinary malarial neuralgias.

Persistent insomnia or unrefreshing snatches of sleep filled with painful dreams add to the patient's distress. Delirium of a mild type is usually present, and is often marked when the fever is slight. In exceptional cases it becomes so furious as to overshadow all other symptoms. Coming on late in the disease it often announces the onset of some complication.

Vertigo, especially on rising, and muscular tremor are not uncommon. Convulsions and coma are rare, but may develop with the initial fever or at any subsequent period.

The extreme muscular weakness, amounting at times to a serious depression of the vital powers, is a peculiar feature of influenza. The debility is wholly disproportionate to the amount of fever or the severity of other symptoms, and generally reaches far into convalescence.

The mental condition harmonizes with the physical depression. When thoroughly under the grippe influence, the patient shrinks from mental as he does from physical exertion, is vacillating, foreboding, and often becomes a veritable "Jacques" in his melancholy.

While restlessness and wakefulness characterize most epidemics, others are equally marked by somnolence. Thus the remarkable epidemic of 1712 is known as the *sleeping sickness*, from the almost universal presence of this symptom.

The disturbances of the digestive organs are generally mild and consist of anorexia, coated tongue, epigastric tenderness, abdominal pains, and constipation. The tongue is heavily furred, flabby, deeply indented by the teeth, and tremulous. The breath, as a rule, is peculiarly offensive. Nausea and vomiting sometimes usher in the attack and may continue throughout its course. At times the force of the disease is expended in the intestinal tract and causes severe colicky pains, tympanites, and obstinate diarrhœa. The stools, at first bilious and fetid, soon take on a dysenteric character or become larger and watery, like the discharges of cholera nostras, and are accompanied with vomiting, leg cramps, and rapid prostration. The digestion remains impaired for some time after the subsidence of the acute symptoms, and not only retards convalescence, but favors a return of the gastro-intestinal derangements upon the slightest indiscretion of diet.

An enlarged spleen is commonly present and bears testimony to the systemic infection.

The urine is scanty, high-colored, and contains abundant urates. Albumin and casts, hyaline and epithelial, are present in a limited number of cases not necessarily of the gravest type. The integrity of the kidneys is rarely permanently impaired. Cystitis is sometimes met with, and retention of urine in elderly persons is tolerably common.

The presence of an hemorrhagic tendency has been remarked by many observers. Epistaxis and menorrhagia are the most, and cerebral hemorrhage the least common of the accidents dependent upon this tendency.

Eruptions are occasionally seen, of which herpes, urticaria, and erythema constitute the chief examples.

The disease attains its height on the second or third day and then rapidly declines, covering a period of from four to seven days in its full evolution; but in the graver cases, or in those disturbed by complications, recovery may be indefinitely delayed.

Convalescence is often announced by the appearance of some critical discharge, such as profuse sweating, a copious secretion of bronchial mucus, a free discharge of sedimentary urine, or a profuse diarrhœa.

After complete apyrexia has ensued, there is not infrequently a temporary return of the fever and other symptoms not dependent upon the presence of a complicating disorder. This new outbreak is usually of brief duration, and should be considered an exacerbation rather than a relapse. It is apt to appear on the fifth or seventh day of the disease, and is oftenest seen in those who have committed some error of diet or have undergone some exposure. True relapses are, however, not uncommon or free from danger.

Complications and Sequelæ.—While there has been of late a tendency to exaggerate the frequency and importance of the complications and sequelæ of influenza, the fact remains that there is scarcely another disease so liable to intercurrent disorders or to serious after-effects. The more common of these are divisible into two groups: First, those which are the direct outgrowth of the lesions in the mucous membranes and parenchymatous tissues; and, second, the sensory-motor derangements, which result from the action of the grippe toxin upon the cerebrospinal centres. Among the rarer affections belonging to the first group may be mentioned circumscribed ulceration of the vocal cords, abscess of the larynx, œdema of the glottis, and paralysis of the muscles of the throat.

Otitis media is comparatively common. The inflammation does not, as a rule, proceed to suppuration, but is rebellious to treatment and occasionally ends in mastoiditis. In fact, more cases of mastoid disease requiring operation are attributed to influenza than to any other constitutional disease.

It is worthy of remark that the pain in the mastoid region is often comparatively slight even when the local disease is extensive and severe.

Bronchitis and pneumonitis are by far the most frequent and fatal complications of this group. Authors have endeavored to show that these affections, when associated with influenza, are peculiar in nature and symptomatology. According to Elliott "the grip-lung has a long and varying condition of passive blood stasis unaccompanied by râles. If resolution occurs within three or four days, it is accompanied by large mucous râles, and no time is given for the slow appearance of bronchial breathing or bronchophony; but during the long-continuance of the blood stasis an exudation occurs, increasing slowly, which will give in time some bronchophony and bronchial breathing, but never so complete as in pneumonia. Resolution never occurs in these cases with the suddenness that characterizes it in acute pneumonia. The condition passes off as gradually as it is formed. The sharp, clear-cut, and sudden phases of the pneumonia attack separate it clearly from the obscure, irregular, and slow phases of the grip-lung."

Da Costa, in a clinical lecture, describes the characteristic influenza lung as one "in which intense congestion occurs, with patches of collapse and with spots of localized consolidation here and there, if consolidation happen at all. Yet there are instances in which real croupous pneumonia takes place, involving considerable portions of the lungs. But these are comparatively rare, and true lobar pneumonia is not nearly so characteristic of the influenza lung as the other form."

Osler, with whom the writer is in full accord, admits that pneumonitis complicating influenza sometimes runs an atypical and very obscure course; but these cases are exceptional, and all the anomalies mentioned by writers as peculiar to influenza are found in many large series of cases of pneumonia.

It is highly important to bear in mind what has been previously stated, that lung complications are liable to creep on insidiously, and that in the presence of anomalous symptoms, whether referred to the respiratory tract or not, the chest, as a matter of routine, should be carefully interrogated. Pleurisy and empyema are not uncommon complications. As a matter of fact, when pleurisy occurs it is apt to take on the suppurative form. Abscess of the lung has been noted. That influenza bears an etiological relation to phthisis pulmonalis, especially in the presence of the disposition, can no longer be doubted. It is furthermore a matter of common observation that consumptives fare badly during the prevalence of the epidemic influence.

Watson and Curtin call attention to the fact that during the recent epidemics many chronic catarrhal cases in which the lungs were involved resembled closely, and were often mistaken for, phthisis. There were present night sweats, cough, diarrhœa, fever, and emaciation, while the physical signs also agreed with those of phthisis in all but dulness on percussion, which was absent. These writers, in speaking of the relationship between phthisis and influenza, make the following remarkable statements: "The catarrhal condition remains and causes a breaking down of lung tissue. These cases, while presenting the physical signs of phthisis and terminating finally in death, showed during life, on examination of sputum, no bacilli. In the fall of 1890, in the Philadelphia Hospital, the sputa of fourteen cases of phthisis examined (several times and by different methods) for bacilli showed them abundant in four, few in six, absent in four cases. In the fall of 1891, after most of the old cases of phthisis had died, twelve out of twenty-eight cases were found free from bacilli, and invariably with histories dating from an influenzal attack."

Thrombosis, both arterial and venous, is not very rare either as a sequel or as a complication. Leyden and Guttmann have alone collected twenty-eight cases of phlegmasia alba dolens.

The nervous disturbances which occur during and after grippe are equally important.

Althaus reflects the opinion of neurologists in the statement: "That as a powerful etiological factor of protean forms of nerve disease influenza stands *facile princeps* among all infectious fevers."

The organic nervous diseases most frequently observed may be enumerated, in the order of their frequency, as neuritis, meningitis, myelitis, and cerebritis.

Multiple neuritis is less common than the local forms, of which latter neuritis of the supra-orbital, intercostal, and sciatic nerves are oftenest met. But "isolated neuritis of almost every cranial nerve has been recorded with such resulting conditions as optic atrophy, loss of smell and taste, ophthalmoplegias, both internal and external, oculo-motor, facial, bulbar and pseudo-bulbar palsies of various types, including true pneumogastric paralysis" (Mills).

Leptomeningitis (pia-arachnoid) and cerebro-spinal meningitis are the commonest types of meningeal inflammations.

Bristowe has reported two cases of cerebral abscess, and has seen others in which the symptoms would justify such a diagnosis.

Convulsions have been repeatedly observed, and in a few instances the epileptic habit has been permanently established. Mills has seen two cases.

Poliomyelitis anterior is the form of spinal-cord disease most frequently associated with influenza. Temporary paralysis of one or more limbs, evidently of spinal origin, is occasionally seen. Abolition of the patellar reflex has been noted.

Neuralgic attacks, severe, persistent, and involving any of the nerve trunks are perhaps the commonest of the post-influenzal neuroses. The rekindling of old and fading neuralgias during convalescence is another of the curious features of the disease.

Neurasthenia, both cerebral and spinal, hysteria and hystero-epilepsy, with their illimitable repertory of disease mimicries, were frequent sequels in the late epidemics.

Insanity is not rare. It usually takes the form of melancholia, with hypochondriacal or religious delusions and decided suicidal impulses. Leledy, Ladame, and others believe that influenza may act either as an exciting or as a predisposing cause, but that there is always an antecedent acquired or inherited predisposition. The onset is often sudden and bears no relation to the severity of the febrile attack. The insane are less disposed to contract grippe than the sane, and its occurrence is sometimes attended by a remission in the mental symptoms. Althaus also recognizes as a rare post-grippal neurosis a peculiarly rapid—galloping—form of general paralysis of the insane, of which he has seen a few examples.

Biermer, Gottschalk, and others remark upon the frequent occurrence of severe hemorrhagic endometritis. In these cases the uterus is enlarged and sensitive, and the hemorrhage profuse. It has long been known that women sick with influenza were subject to profuse and painful menstruation, and, on the other hand, that the menses were apt to return to those suffering from amenorrhœa. Pregnant women are liable to abort under the same conditions.

In conclusion, it is all important to bear in mind the tendency of influenza to develop latent into active disease. This is particularly noted in lesions of the heart, lungs, and kidneys. Under the baneful influence of a grippe infection a slight albuminuria may be changed into a rapidly fatal nephritis, or a mild cardiac affection may speedily result in degeneration of the muscular walls of the heart with dilatation of its cavities, or a slumbering tuberculosis may be awakened into fatal activity.

Prognosis.—Uncomplicated cases of influenza end in

recovery. The prognosis is modified somewhat by the character of the prevailing epidemic and the physical condition of those affected. The extremes of life and those debilitated by disease or vicious habits bear influenza badly. Infants are fortunately less likely than adults to contract the disease. The mortality is largely due to complications or to its development in those suffering from advanced pulmonary, cardiac, or renal affections.

Diagnosis.—Influenza is not likely to be mistaken in its epidemic form. The numbers affected, the fever, the catarrhal phenomena, the prominence of the nervous symptoms, and the rapid course will readily establish the diagnosis. Influenza bears a striking resemblance to non-specific catarrh caused by atmospheric changes, but it is only in those isolated cases which herald the approach of an epidemic that this similarity could mislead.

The only difficulty in diagnosis attaches to those cases occurring during the prevalence of an epidemic of grippe in which coryza is absent and the symptoms are those of a general fever. Some of these cases bear a striking resemblance to typhoid fever. The continued fever, delirium, epistaxis, diarrhœa, and prostration are common to both, but the temperature charts and progress of the diseases are very dissimilar.

In other cases the suddenness and violence of the onset, the variety and intensity of the nervous symptoms, and the irregular febrile movement are very like epidemic cerebro-spinal fever.

Dengue and the nervous type of influenza have many symptoms in common, but the former is pre-eminently a disease of tropical climates. In our own country it is confined to the Gulf States and rarely extends beyond the thirty-second parallel. Only once (1780) has it reached as far north as Philadelphia. It was at that time described by Dr. Rush under the name of bilious remitting fever.

Prevention.—Little has been attempted in the way of prophylaxis, Notwithstanding the improved technique of modern bacteriologists, thus far all attempts to isolate the specific toxin have been negative, nor has any one yet succeeded in producing a protective or curative serum. It has, however, been proposed, on account of its undoubted contagiousness, to isolate those suffering from the disease and to close the schools and places of public resort during an epidemic.

But the volatile nature of the pathogenous material and the remarkable rapidity with which influenza spreads—its whole career from inoculation to full development being only a matter of hours—will doubtless render abortive all attempts at quarantine.

It has been abundantly proved that during the prevalence of the epidemic influence those who are over-fatigued or much exposed in the open air, especially at night, are more susceptible to the disease. The lesson to be drawn from this fact is obvious and should be heeded by the aged and debilitated.

Considerable testimony has been collected to show that vaccination with animal lymph furnishes immunity against influenza. Dr. Goldschmidt, of the Island of Madeira, was the first to call attention to this fact. The island suffered from a double invasion of smallpox and grippe, and in investigating the relationship between the two diseases he ascertained that out of 112 persons successfully revaccinated not one contracted influenza; and of 98 in whom revaccination was attempted but failed, only 15 showed any symptoms of the disease. In an isolated villa there were 27 inhabitants, of whom 12 had been recently vaccinated. These all escaped, but the 15 who had not been vaccinated were affected. Althaus, who strongly advocates the protective power of vaccination, refers to illustrations which came to his knowledge, in which small clusters of recently vaccinated persons remained untouched, although surrounded by and freely mingling with grippe-stricken people. The well-known immunity of children is likewise attributed to the protective influence of vaccination. It is stated that in the German army, where revaccination is systematically enforced, influenza was less prevalent and less fatal than in civil life. While influenza affected forty-two per cent. of the population of Berlin, and about sixty-four per cent. of that of Paris, its prevalence in the German army amounted to only a little more than eleven per cent. A number of garrisons were entirely spared, while the inhabitants of the adjacent towns suffered severely, and it is further stated that no garrison was ever affected with influenza when the civil population escaped. When an outbreak did occur in a military post, it was found that those affected were almost exclusively soldiers who had not been recently revaccinated. And, finally, statistics show that the average duration of the disease is shorter, complications are less frequent, and the death rate is lower in military than in civil life.

Treatment.—Influenza is a self-limited disease of short duration. There is no specific and the treatment is largely symptomatic. In view of the many severe complications and sequelæ which may arise, every case should be regarded as serious enough to necessitate confinement, at least within doors, until the fever has disappeared. The experience of the late epidemics demonstrated that those who remained in bed from the beginning of the illness not only appreciably shortened the attack but made a pleasanter convalescence.

Rest in bed, a mild calomel purge or saline draught, cooling drinks, an occasional Dover's powder to quiet cough, and the employment of such general hygienic and dietetic measures as are indicated in acute infectious diseases will meet every indication in simple, uncomplicated cases.

In the futile search for a specific all of the leading remedies, new and old, received an extensive trial in the recent epidemics. The coal-tar derivatives—acetanilid, antipyrin, and phenacetin—were all extensively used, but phenacetin, from its greater safety and the absence of unpleasant after-effects, deservedly had the greatest popularity. Given early in the attack, it rarely failed to relieve the headache, lower the temperature, and lessen the muscular soreness and tired feeling. The writer obtained excellent results from its combination with quinine or salol and caffeine.

Salicin is an eligible remedy. It acts as a mild tonic, reduces temperature, excites perspiration, and relieves the gastro-intestinal irritation. Its taste is objectionable. Quinine in medium-sized doses may be advantageously given throughout the sickness, but is especially indicated in the later stages and in delayed convalescence. When the head pain and muscular soreness are prominent the salicylate of cinchonidine is preferable to quinine, and is supposed to possess decided prophylactic powers. Strontium salicylate (gr. v. to xx.) is a remedy of great value and is better borne than the sodium salt. The insomnia, as a rule, readily yields to the bromides or chloralamid. The singularly depressing effects of grippe on the mental and physical powers strongly contraindicate the use of lowering measures and remedies. Stimulants, preferably some form of ammonia or alcohol, should be resorted to on the first evidence of failing strength. In the presence of great thoracic distress or heart failure a timely use of the heart tonics, of which digitalis and caffeine are the best representatives, may avert the threatened danger. Strychnine alone, or in combination with tonics, is the most reliable drug with which to tone up the feeble heart so often left by grippe.

Gastro-intestinal irritation is best met with salicin, bismuth, preferably the subgallate, resorcin, and the salicylates.

Local applications to the inflamed mucosa add greatly to the patient's comfort and favorably influence the course of the disease. In the writer's experience nothing gives such grateful relief as the occasional spraying of the throat and nose with a weak solution (one to two per cent.) of cocaine and menthol in benzoinol, or albolene. A gargle of boracic acid or salicylate of soda in glycerin and water soothes the irritation of the mouth and throat. Dobell's solution in the form of spray, or the inhalation of steam, pure or medicated with eucalyptus, creosote, or terebene, is of signal benefit in allaying the laryngeal

and bronchial irritation. Troublesome cough is readily controlled by the old-fashioned Brown's mixture, or by small doses of codeine in syrup of wild cherry.

In recent epidemics the writer has gotten excellent results from heroin (gr. $\frac{1}{12}$–$\frac{1}{24}$) either alone, or when secretion was free, in combination with ammonium chloride (gr. v.–x.) and syrup of squills (♏ x.–xv.).

In the graver types of influenza, or when the course is anomalous, care must be taken not to overlook complications, which often, especially those of intrathoracic origin, steal on insidiously. These must be managed according to the principles of treatment laid down on other pages of this HANDBOOK.

Delayed convalescence will call for a prolonged course of tonics, and, in many cases, for an outing at the seashore or in the mountains. *William Judkins Conklin.*

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INGROWN TOE-NAIL.—This affection is characterized by an inflammation of the soft parts underneath and alongside the edge of the toe-nail. It may be congenital, but more commonly it is met with in adults. In occasional instances it would seem to be hereditary. Its most frequent location is on the outer side of the great toe, although it not infrequently involves both sides of the toe, and even of both large toes. The disease seldom occurs in the smaller toes, and is of comparatively slight importance when it does.

Beginning insidiously with pain and soreness underneath the side of the nail, which are increased by pressure, the affection often terminates in suppuration and ulceration. The granulations become exuberant, the parts about the nail become hypertrophied, and the whole toe is swollen, tender, and painful, rendering the patient totally unable to wear a boot, or even to walk. The nail also becomes deformed. Its edges curve in and act as a foreign body, constantly irritating the inflamed tissues. Pus collects underneath the nail, decomposes, and tends not only to aggravate the suffering, but to keep the toe in a filthy condition. The duration of the disease is often protracted, many people suffering from it for months or even years, before obtaining permanent relief.

CAUSE.—Tight or ill-fitting boots are frequently the cause of this affection. High and narrow heels, narrowness of toe, and insufficient length, are common and important defects in boots, shoes, and slippers. Every step taken upon a high heel tends to push the foot farther into the shoe, and thus to crowd and cramp the toes, and not infrequently the affection under consideration is the result. The accumulation of dried epithelial débris under the nail also acts as an irritant. Paring the corner of the nail too closely tends to produce this disease by allowing the soft parts which grow more rapidly, to rise up and obliterate the groove that the nail should occupy. As this latter comes forward again it necessarily impinges upon the soft tissues, and may excite inflammation. A markedly convex nail bordered by thick masses of soft tissues predisposes the toe to this affection.

TREATMENT.—This may be palliative or radical. The cause should be removed, if practicable. The nail should be trimmed squarely across the end, and the edges should be allowed to project beyond the free margin of the flesh.

The soft parts are to be kept well pressed back from the nail at its root and sides, and the epithelial débris is to be frequently removed. The boots should be of good length, wide across the toes, and should have low, broad heels.

In the lighter cases relief may at times be obtained by scraping the nail thin with a knife or, better, with a piece of glass, and cutting a deep notch in the centre of the free border. A bit of lint or of cotton may be drawn under the edge of the nail to raise it from the sensitive matrix, and to give exit to any pus which may have accumulated underneath. The same object may be obtained by means of an elastic cord passed under the border of the nail, the ends being secured to the dorsum of the foot by adhesive plaster. Agnew made use of a piece of cork, cut in a peculiar shape, to separate the nail and the flesh. Should there be much inflammation at any time, it is to be treated with water dressings, or with flaxseed-meal poultices. A starch poultice is also an admirable application in many cases.

One of the best local applications to repress exuberant granulations is the powdered nitrate of lead. It is to be dusted upon the parts every day, until a crust is formed, underneath which healing will frequently take place. Should the crust become loosened by the suppuration, it may be removed and fresh powder applied, until the granulations show a tendency to a healthy cicatrization.

The cause of the affection having been removed, many cases of only moderate severity may be satisfactorily managed in the manner above described. Not infrequently, however, either from neglect or from improper treatment, the tissues have become so extensively inflamed that more radical measures are required. Several methods for obtaining a permanent cure have been recommended. The old one of splitting the nail and removing a portion without destroying the matrix has very properly been discarded, as the benefit derived from the procedure was usually only temporary, and the trouble was very apt to reappear with the growth of the nail. Removal of the entire nail with destruction of the matrix is seldom, if ever, necessary.

The operation which was brought to the notice of the profession many years ago by Dr. B. E. Cotting, is efficient, and, barring a rather tedious convalescence in some

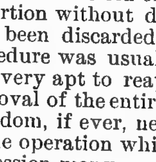

FIG. 2799.

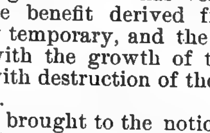

FIG. 2800.

cases, is satisfactory. It consists in removing all of the soft parts overlying the infleshed nail, leaving the latter uncovered and freely exposed, as is indicated in Figs. 2799 and 2800. The cicatricial contraction following the healing of this wound tends to prevent the nail from again becoming embedded in the soft tissues. This is a

very good operation, but the following is preferable from the fact that the convalescence is much shorter, and the results are as good.

The nail is split so as to remove about one-quarter of it on the affected side. The incision is to be extended well back toward, but not into, the joint. Another incision extends from this one along the side of the toe near the nail, thus removing a very thin strip of the inflamed tissues, leaving a clean fresh wound. Particular care should be taken to remove the matrix along with the bit of nail. Unless this is done thoroughly, the new growth of nail will very likely give the same trouble as the present one. This is the key to the success of the operation. The wound is to be closed with sutures, one or two of which may be passed through the nail, or that portion of the flap may be kept in place with adhesive plaster. If the operation is done under careful aseptic precautions, the wound should be well in a week, and the patient enabled to wear a loose shoe soon after. This is the best operation thus far suggested for a radical cure of this troublesome affection. *George W. Gay.*

INHIBITION.—Inhibition is derived from the Latin word meaning restraint. It refers to any influence which controls or retards. From a physiological standpoint, inhibition is commonly referred to as any influence which restrains or even prohibits movement of the parts concerned. Although some of the most striking illustrations of inhibition have to do with the retardation of movement, it by no means follows that inhibition should be limited to this kind of phenomenon alone. There is some evidence that under certain conditions, or in particularly susceptible individuals, sensation (pain, etc.) and chemical activity, as represented by changed secretions, may be inhibited to a greater or less extent. The term inhibition in its physiological sense first came into use from the study of the action of the vagus nerves upon the heart. This phase of the subject will therefore be dwelt upon in some detail.

Historical.—In their experiments in 1845 the Weber brothers showed that when an interrupted electric current was used for stimulation, and one electrode was placed within the nostril of a frog and the other on a cross section of the myel at the level of the fourth or sixth vertebra, the stimulus caused the heart to stop beating. This experiment led to the discovery of the function of inhibition. By further experiments the Webers localized more definitely the source of inhibitory power as being situated between the optic lobes and the calamus scriptorius—or, in other words, in the region of the oblongata. Later, Eckhard, by using a mechanical stimulus—the prick of a needle,—more minutely localized the inhibitory centre in the frog, and found it to be between the cerebellum and the tip of the calamus scriptorius. Labordi, also by the needle method of excitation, located the vagus centre in the cat at a point in the middle of the spinal bulb, lying in the lateral part of the floor of the fourth ventricle. At this spot there is situated a mass of gray matter, which forms the accessory nuclei of the hypoglossal, spinal accessory, and glossopharyngeal nerves.

Comparative.—The different conditions existing in the various groups of animals respecting the form, structure, innervation, and temperature of the heart itself, are naturally correlated with some difference in reaction to inhibitory influences. As will be shown later on, different parts of the heart will respond in a different degree to inhibitory stimuli. Even among the various Invertebrates investigated, some have been shown to possess a regulative mechanism for the heart. Ransom has shown that in the octopus and in the squid, both inhibitory and accelerator nerves are present. The American crab, *Callinectes hastatus*, is also provided with accelerator and inhibitory nerves which pass into a pericardial plexus. The land snail, *Helix*, possesses cardiac inhibitory nerves as shown by numerous observers. The sea snail, *Aplysia*, on the other hand, has been found to possess an accelerator but no inhibitory nerve

The presence of a cardiac inhibitory mechanism in numerous Invertebrates would naturally strengthen the supposition that a similar condition should exist in the Vertebrates. Such an assumption has hitherto been generally accepted without question or proof to the contrary. A recent article by Greene (*Amer. Jour. Physiol.*, 1902) shows that in the hagfish, *Polistotrema stouti*, there are no cardiac regulative nerves whatever. In the literature at present available the writer has been unable to find any other record of the absence of an inhibitory cardiac mechanism among the Vertebrates. There are, of course, examples where much cardiac resistance has been shown toward inhibitory influences, but some restraining effect has been obtainable. Greene concludes that in the hagfish, one of the lowest of the Vertebrates, a condition exists comparable to the heart of an embryo before the nerves have entered it, and that any regulation of the heart's action must depend upon conditions which affect the cardiac muscle directly, such as tension, nutrition, etc. The volume and pressure of the blood coming to the heart and the changes in the pressure upon the viscera by the body movements undoubtedly exert a decided influence upon the hagfish heart.

Gaskell concludes, from his observations among the cold-blooded animals, that, with the exception of the Amphibia, stimulation of the vagus has little or no inhibitory effect upon the ventricle, although other parts of the heart are affected.

Greene states that among the Elasmobranchs several sharks and rays have been shown to possess inhibitory nerves for the heart, and has himself demonstrated the presence of such nerves in one species of shark, but any specific action upon the ventricle itself is not mentioned. Among the Teleosts, Gaskell mentions the eel and toadfish as examples of this group in which the ventricle shows little or no inhibitory effects. Fishes are mentioned in the original list of animals given by the Weber brothers in which cardiac inhibition was produced by vagus stimulation, but here again there is no specific mention of the ventricle. In the Amphibia (frog, toad, newt, and necturus), on the other hand, the ventricle is inhibited in the same way as is the auricle.

Knoll (*Arch. f. d. ges. Physiol.*, Bonn, Bd. xlvii., S. 595), among other things, states that in the heart of the pigeon, which was included in his experiments, the ventricles reacted normally to vagus stimulation in the same way as the atropinized ventricles of the mammal. As atropine paralyzes the inhibitory nerve endings, stimulation of the vagus, under this condition, exerts no inhibitory effect upon the mammalian ventricles. It seems reasonable, therefore, that the inference to be drawn is that the pigeon ventricle is normally insensible to inhibitory influences from excitation of the vagus. This fact has an interesting relationship to the view commonly held that the birds sprang from the reptiles.

In the group of Mammals (cat, dog, rabbit, rat, hedgehog, guinea-pig) it has been well demonstrated that vagal stimulation inhibits the action of the ventricles as well as the auricles.

In classifying the results obtained, so far as ventricular inhibition is concerned, the Amphibia and Mammals may be placed in one group, characterized by ready ventricular response to vagal excitation; and, following Gaskell, the Teleosts, Reptiles, and pigeon may be placed in another group in which there is little or no ventricular response when the vagus is excited.

As the writer is unable at the present time to obtain definite information with regard to the specific effects of vagal stimulation upon the ventricle of the Elasmobranchs, it is doubtful to which group they should be assigned. Nor is there any information available as to the effects upon the ventricle of the Dipnoans—the lung-breathing fishes. Gaskell suggests that it may be assumed that the same phenomena may be found in this group as in the Amphibia. The hagfish apparently holds a unique position among Vertebrates, on account of the absence of any extrinsic nervous mechanism for regulating the action of the heart.

Cardiac Inhibitory Mechanism.—A cardio-inhibitory centre in the oblongata with afferent and efferent nerves and the heart itself represent the various parts, two or

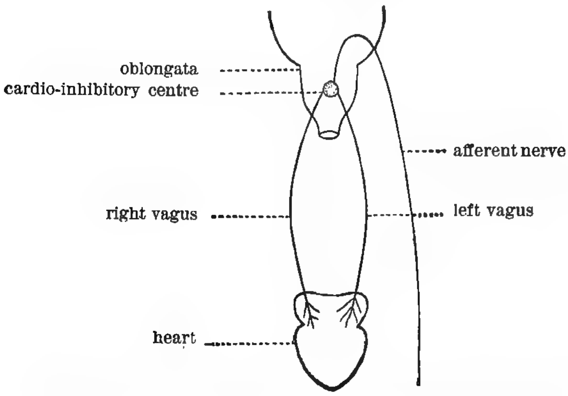

Fig. 2801.—Schema Showing the Relation of the Cardio-Inhibitory Centre, Afferent and Vagus Nerves to the Heart.

more of which are necessary to accomplish inhibition. In experiments, stimulation of the vagus nerve which contains the efferent or inhibitory fibres and the heart itself represent the two necessary parts of the mechanism concerned in the process. Direct excitation of the centre would involve three of the parts, and reflex stimuli would necessitate the use of all of the parts above mentioned.

The Weber brothers pointed out the fact that a weak stimulation of the vagus nerve of the frog not only slows the heart, but also weakens the contractions. The latter fact was largely overlooked in the various controversies that followed, until Coats, in 1869, showed that the contractions of the heart, as registered by a mercurial manometer, were markedly diminished in force upon stimulation of the vagus nerve. These observations were followed by those of Nuel, who also noted that the contractions of the auricle were diminished to a greater extent than those of the ventricle. Gaskell and Heidenhain, in 1881 and 1882, confirmed the above phenomena.

Fig. 2802.—Tracing Showing the Diminished Force and Frequency of the Heart Beat when the Vago-Sympathetic is Stimulated.

If one vagus be cut there will be but little change in the beat of the heart—probably a slight acceleration. If the other vagus be also divided there will be a marked increase in the heart's action. Such an experiment shows that the vagi serve as channels for restraining or inhibitory influences keeping the heart's movements in check. With these influences removed, the movements occur with greater frequency.

Stimulation of the vagus from the centre downward causes the heart to beat more slowly or arrests its action in diastole. The result depends upon the strength of the stimulus employed; feeble stimuli slow the heart, while strong stimuli arrest it in diastole. "Division of the vagi lets the heart go; their stimulation holds the heart in." In this respect there is a phenomenon totally opposite to that possessed by the motor nerves and muscles in general; the vagi do not excite but restrain the contraction of cardiac muscle, or, if the stimuli be sufficiently strong, will cause an actual relaxation.

Stimulation of the vagus does not produce an immediate effect upon the heart. Donders, Prahl, and Nuel observed a latent period between the moment of excitation and any visible response on the part of the heart. This

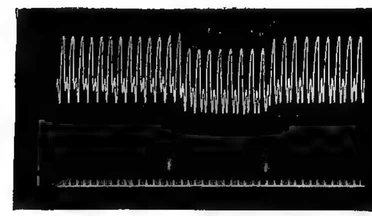

Fig. 2803.—Showing the Effect of a Very Weak Interrupted Current upon the Heart's Action. The lower line is the time tracing in seconds; the two short verticals just above it show when the stimulus was applied to the vagus and when it was removed; secondary coil 19 cm. from the primary. (Brodie.)

period has been variously estimated as lasting from one-twentieth to one-fifth of a second—much longer than the latent period of a voluntary muscle. It is usually of such length that at least one heart beat or cardiac cycle occurs after the commencement of stimulation.

On the other hand, the effect upon the heart is not

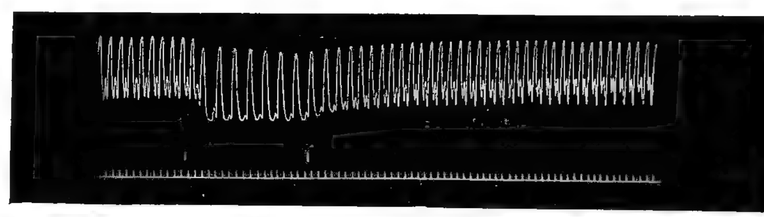

Fig. 2804.—Vagus Excited by Weak Interrupted Current. The short verticals between the heart and time tracings show when the stimulus was applied and removed; secondary coil 15 cm. from the primary. (Brodie.)

removed immediately upon the withdrawal of the stimulus, so that the heart is still inhibited for a time after all excitation has ceased. This is described as the "after-effect," and, in its most typical form, is a continuation of arrest followed by recovery to and beyond the normal.

It has also been found that a prolonged stimulation of the vagus is not able to keep the heart in a state of arrest for an indefinite period, but that it will "escape" from the inhibitory influence, and although the stimulation is kept up the heart will recommence its beating, and may even beat more strongly than before. A most interesting feature in this connection is that if stimulation of one vagus is kept up until the vagus arrest has come to an end, stimulation of the second vagus will stop the heart.

The two vagus nerves, however, are not equal in power. Stimulation of the right nerve is usually more effective than that of the left, though the reverse is sometimes true, and again there may be no perceptible

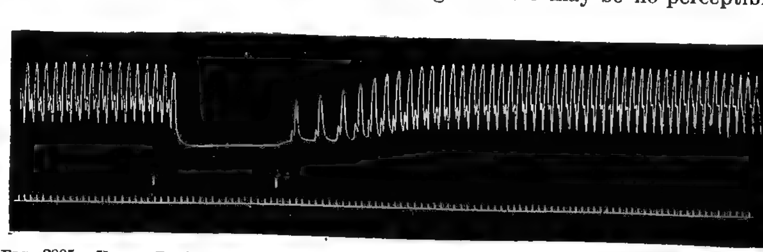

Fig. 2805.—Vagus Excited by Slightly Stronger Interrupted Current. Secondary coil 14 cm. from the primary. The short verticals between the heart and time tracings indicate when the stimulus was applied and when removed. (Brodie.)

difference between the two. Differences of this kind have also been noted according to the species of animal experimented upon.

A partial explanation for some of the variable inhibitory results, and also having a bearing upon the escape of the heart from vagus control, is the presence in the vagus of accelerator fibres, which come into action as the true inhibitory action wears off. Such accelerator fibres have been isolated in the frog, and their existence, experimentally at least, in the mammalian vagus, if not proved, is highly probable.

In Mammals the inhibitory fibres are derived from the spinal accessory by its internal branch; if the spinal accessory be torn out by the roots and its fibres allowed to degenerate, stimulation of the vagus will no longer produce cardiac inhibition (Waller, 1856).

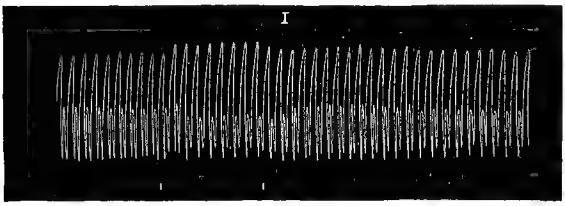

FIG. 2806.—Stimulation of the Right Vagus. The accelerator fibres overshadow the inhibitory fibres in this case and acceleration is produced instead of inhibition. The short verticals just below the heart tracing show when the stimulus was applied and when removed. (Brodie.)

In general, either one of two effects may be noted upon the amphibian or mammalian heart with a moderate stimulation of the vagus: there is usually diminished force and frequency of the auricular as well as the ventricular beats, followed by increased force and frequency; or there may be exceptionally no primary diminution, but an immediate increase of force and frequency.

These results also indicate the presence of two kinds of fibres in the vagus—or more properly the vago-sympathetic—viz., the inhibitors which give the usual, and the accelerators which give the exceptional results. In the usual results the accelerators are overshadowed for the time being by the inhibitors. Stimulation of a fresh vagus nerve in connection with a vigorous heart gives the usual inhibitory effects; stimulation of a fatigued or otherwise weakened vagus with a sluggish heart is quite likely to give the exceptional effects. Direct excitation of the normally beating heart generally gives inhibition; direct excitation of a dying heart, which has almost or just ceased to beat, temporarily restores the rhythmic beat.

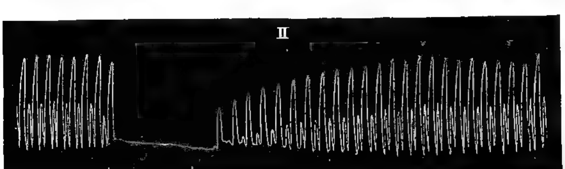

FIG. 2807.—Stimulation of the Left Vagus. In this case the inhibitory fibres overshadow the accelerator and the heart is stopped in diastole. Stimulus applied and removed as shown by the short verticals. (Brodie.)

According to Waller, the cardiac muscle within certain limits is more or less easily modified by inhibitory as well as accelerator influences, according to a higher or lower temperature.

Cardiac inhibition has been noted in man by Czermak and Concato, by compressing the vagus in the neck with the finger; but the experiment is accompanied by danger and ought not to be undertaken. Waller has also referred to experiments in which inhibition was produced upon the heart of executed criminals, the inference being commonly held that inhibitory phenomena occur in the heart of man similar to those in the hearts of other Mammals.

Parts of the Heart Principally Affected.—Experimental evidence points to the fact that in all cases the auricles are inhibited to a much greater extent than the ventricles, even in the Amphibia and Mammals in which both portions easily respond; in certain other Vertebrates, as has been stated, inhibition is inclined to stop in the auricles and hesitates or does not pass over into the ventricle. Much discussion has arisen as to whether the inhibitory effects, arising from excitation of the vagus, are brought about by the action of the vagus upon the cardiac ganglia—the intrinsic nervous mechanism,—or if there is direct action of the vagus upon the muscle itself. There seems to be increasing evidence that the latter view is correct. As pointed out by Gaskell, the fact that a diminution in strength of contraction as well as in rate, taken with the well-known fact that the force of the cardiac contraction does not vary with the strength of the stimulus, would indicate that the inhibitory nerve acts on the muscle itself, and not by decreasing a stimulus from motor ganglia. This view rejects the idea that inhibition is caused by merely diminishing the impulses to the muscle, but favors the conception of direct vagus (inhibitory) action upon the muscle substance.

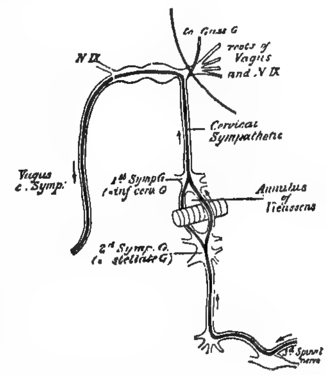

FIG. 2808.—Cardiac Nerves of the Frog. (Foster.)

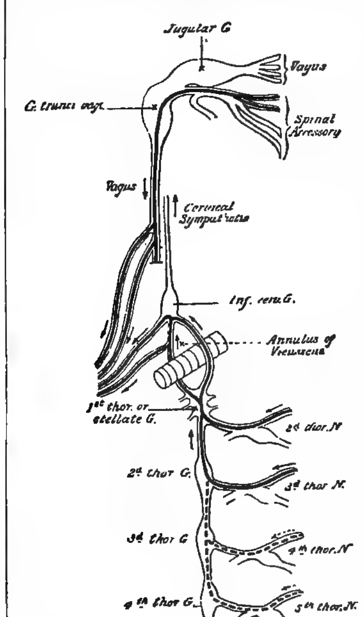

FIG. 2809.—Cardiac Nerves of the Dog. (Foster.)

Quite early in researches concerned with inhibition, it was noted by Schiff that the cardiac muscle both of auricle and ventricle in the frog responded less readily to a stimulus during standstill, or even would not respond at all, although the stimulus might be a strong one. Eckhard confirmed this, and the fact is now generally accepted, and is taken as evidence that the vagus diminishes the excitability of the muscular tissues.

Later came the work of Gaskell and Heidenhain, which emphasized the importance of separating the inhibitory from the accelerator fibres in the vago-sympathetic nerve of the

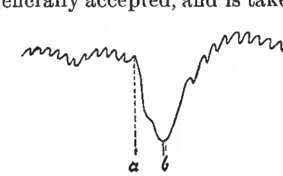

FIG. 2810.—The Effect of Vagal Stimulation upon Blood Pressure. *a*, Vagus excited; *b*, excitation removed.

frog, in order to obtain strictly pure inhibitory action. In the frog the accelerator fibres do not join the vagus until the latter has left the cranium. If the vagus is

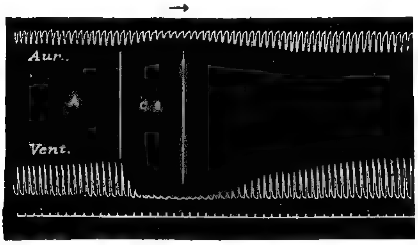

FIG. 2811.—Heart of Frog. Stimulation of vago-sympathetic nerve. Weak current. (Gaskell.)

stimulated just within the cranium, or intracranially, the inhibitory fibres only are excited; while extracranial stimulation of the vagus (or vago-sympathetic), on account of the accelerator fibres which have joined it, give somewhat variable results according to the proportion of the two kinds of fibres in it.

Employing intracranial stimulation of the vagus, Gaskell has noted three interesting differences as contrasted with extracranial stimulation. In the first place, he has been able to obtain absolute standstill of the heart with a strength of current immensely weaker than is required to produce any effect when the vago-sympathetic is stimulated. In the second place, he noticed that the cardiac standstill lasted for a surprisingly long period after discontinuance of stimulation. In one of his experiments in which the vagus was excited intracranially for thirty-eight seconds, the heart remained absolutely still for two hundred and ninety seconds, or for two hundred and fifty-two seconds *after* the stimulus was removed. In the third place, it was possible to keep the heart absolutely quiet for a much longer time than when the vagus was stimulated in the ordinary manner. The frog heart has been kept entirely quiescent for as long a period as twenty-eight minutes with a continued weak intracranial excitation of the vagus. The heart, under these conditions (absence of accelerator fibres), apparently loses or has greatly retarded its power to "escape" from the inhibitory effects.

According to McWilliam, there are three conceivable causes for stoppage of the ventricle to be considered in connection with the arrest of its rhythmic action as a result of vagus excitation: 1. The absence of those incitations to contraction which normally determine the ventricular sequence—such absence being due (*a*) to a cessation of the auricular beats which normally lead off the ventricular beats, or (*b*) to a block in the propagation of the contraction from auricles to ventricles. 2. An inhibitory influence acting through the vagus nerve on the inherent rhythmic property of the ventricles. 3. A combination of the two preceding conditions.

Cardio-Inhibitory Centre.—It is assumed by many observers that this centre in the oblongata is in a state of tonic excitement; that there is a continuous, uninterrupted, regulating, and inhibitory action of this centre upon the heart through the fibres of the vagus.

FIG. 2812.—Heart of Toad. Long stimulation of the intracranial roots of the vagus with moderately strong current. (Gaskell.)

Direct Excitation of the Centre.—Sudden anæmia of the oblongata, by ligation of both carotids and subclavians, causes slowing and even temporary arrest of the action of the heart; sudden venous hyperæmia acts in a similar manner, and can be produced by ligating all the veins coming from the head; an increased amount of CO_2 in the blood, produced either by direct cessation of the respiration or by forcing into the lungs a quantity of air containing much CO_2, will also stimulate this centre; excitation is also produced by an increased blood pressure in the cerebral arteries.

Reflex Excitation of the Centre.—This may occur by stimulation of sensory nerves or nerves containing afferent fibres, *e.g.*, the sciatic (stimulation of the central end of this nerve will slow the heart's action); by stimulation of the central end of one vagus, provided the other vagus is intact; and by stimulation of the sensory nerves of the intestines through tapping upon the belly, or by direct excitation of the splanchnic or of the abdominal or cervical sympathetic. Goltz's experiment succeeds very readily by tapping the intestines of a frog with the handle of a scalpel, especially if the intestine has been exposed to the air for a short time, so as to become inflamed. The reflex arc for this effect is formed by the abdominal sympathetic, the spinal cord and bulb, and the vagi. Almost any form of stimulation of the abdominal viscera

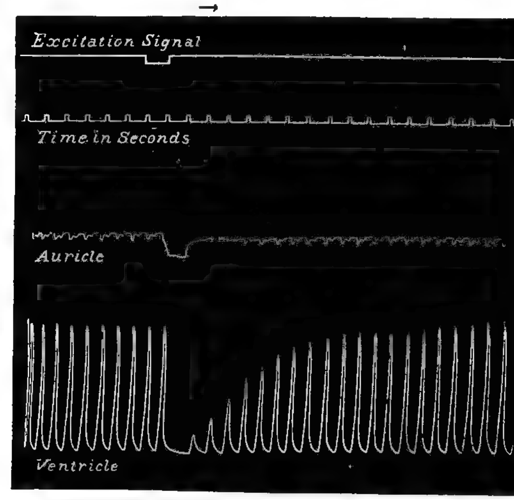

FIG. 2813.—Heart of Toad. Short stimulation of the intracranial vagus roots with current of moderate strength. The change in level of the auricular tracing is due to the movement of the laryngeal and trapezius muscles. (Gaskell.)

produces slowing of the heart. Sudden distention of the stomach may be referred to especially as provoking a reflex of this character. Starvation renders the vagus centre much more excitable.

According to François-Franck, stimulation of the mucous membrane of the lungs and the upper part of the larynx causes slowing of the heart. Excitation of the nasal branch of the fifth nerve always diminishes the frequency of the pulse. Cardiac inhibition is therefore of usual occurrence during the primary stage of inhalation of chloroform or ammonia.

A condition of high intracardiac pressure has been found to render vagus inhibition more difficult, and again, beyond certain limits the arterial pressure cannot be greatly raised, so long as the vagi are intact. There is apparently much to be said in favor of the idea that the terminations of the afferent

nerves on the inner wall of the heart may be stimulated by intracardiac pressure, and thus the controlling centres of the circulation as a whole—vagus, vaso-motor, and respiratory—excited or depressed. If this be true, the heart possesses a mechanism for regulating reflexly, not only its own rate, but the whole circulatory system.

The cardio-inhibitory centre can be excited not only by the character of the blood which comes into contact with it, and by stimulation of afferent nerves (reflex), but also by cerebral stimuli. As is well known, the pulse can be altered by psychical and emotional conditions, and in hypnotic subjects the pulse rate has been observed to undergo a marked change under the influence of suggestion.

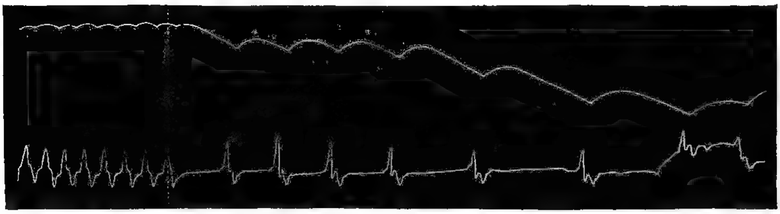

FIG. 2814.—Reflex Inhibition Produced by Inhalation of Ammonia. The upper line is a tracing of arterial pressure, the lower line that of the pulse. (François-Franck.)

Search has been made on the surface of the cerebrum by cortical excitation, to discover if areas were present which might influence the cardiac centre. If suitable strengths of current were used to avoid the excitation of epileptic fits, François-Franck found that stimulation of the motor area with a weak current accelerated the heart, while a strong current slowed the heart. The heart can also be influenced from other parts of the cerebrum. All the cerebral effects are similar to those excited reflexly by stimulation of afferent nerves. As the vagus centre is supposed to maintain a tonic bridle action over the heart, the question arises as to whether this tonus is kept up reflexly by the reception of afferent impulses or whether the centre possesses automatism, as has been suggested by some.

The vagus has been referred to as the nutritive or trophic nerve of the heart, its supposed action, on account of its inhibitory power, being to retard the katabolic processes going on in the heart and thus favor the anabolic or building-up processes. Granting that the vagus acts directly upon the cardiac muscle, and that the impulses are not annulled in the peripheral fibres, as essentially held by Bernard and others, it would appear that the inhibitory impulses are able to lessen or to stop the chemical change in the tissue which leads to contraction. As this chemical change is accompanied by a setting free of energy, it is spoken of as a disassimilatory or katabolic change, so that inhibitory impulses may be said to lessen or stop some katabolic change in the heart. Beyond this it does not seem safe to go at present.

It has been implied by some that when anabolism goes on in the cardiac tissue katabolism ceases; that the two processes are mutually antagonistic. This is certainly not the case in the majority of glands in the body, for, as is well known, the two processes go on in these structures actively at the same time. As yet, however, no true inhibitory fibres have been positively shown to exist in the glandular tissues, and it therefore seems to be an open question as to whether anabolism actually stops katabolism in the tissues in which inhibition occurs.

Inhibition Following Regeneration of Vagus.—It is a well-known fact that when both vagi are cut in a mammal, death soon follows the operation. If, however, the two vagi are cut at different times, sufficiently distant from each other, death does not necessarily occur. As in other nerves, when the vagus is cut the fibres peripheral to the cut degenerate. In the regeneration which follows, in the course of time, do the regenerated fibres exhibit the same inhibitory function upon the heart as before? According to the experiments of Tuckett upon rabbits, it seems that an affirmative answer can be given. After the animals were operated upon, three years were allowed to elapse before the vagus was tested. When the nerve thus operated upon was stimulated, it was found that inhibition of the heart occurred, but not so powerfully as under normal conditions, and the conclusion is drawn that the inhibitory fibres will in time, after complete degeneration and subsequent regeneration, recover their function. From other experiments the inference is also drawn that nerve fibres to striated muscles will recover more rapidly and completely than those going to plain or cardiac muscle.

Inhibition as Affected by Physical Condition.—The experiments of Harrington upon the heart of the guinea-pig show that response to vagal excitation differs markedly according to the time of the year when the experiments were carried on. During the fall and early winter the heart, with an average pulsation of 200 per minute, was very resistant to inhibitory stimuli, it being impossible to bring it to a standstill even when a strong current was employed. During late winter and spring, on the other hand, the heart responded very readily to stimuli through the vagus; a current of only moderate strength sufficing to bring it to a standstill. Later it was noticed that the animals did not live very long or that they died during the experiment. Hygienic conditions were not held to be responsible, as animals were obtained from various localities and the results were practically the same in all. The suggestion is made that the different results, according to the season of the year, are due primarily to a difference in physical condition. In the spring there is a probable lack of body tone, a weakened and debilitated system, affecting also the heart, and under these conditions it became more susceptible to inhibitory stimuli than in the fall, when the conditions were reversed.

Action of Drugs upon the Cardio-Inhibitory Mechanism.—Muscarin, by stimulating the cardiac endings of the vagus, causes the heart to stand still in diastole. Atropine applied in solution to the heart (frog) will set aside the muscarin effect and the heart will beat again. In large doses it will paralyze the vagi; large doses of curare will have the same effect. It is said that a very low temperature or high fever will produce a similar action. Digitalin diminishes the number of heart beats by action upon the cardiac muscle and also perhaps the cardio-inhibitory centre in the oblongata. Nicotine first excites the vagus, then rapidly paralyzes it. Hydrocyanic acid has the same effect (Preyer).

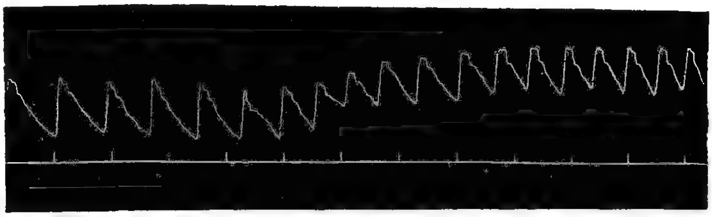

FIG. 2815.—Effect of Sipping Water upon Pulse Frequency; the heart beats faster owing to diminished vagus control, and the blood pressure is raised (man). (Waller.)

Other Forms of Inhibition.—*Vaso-motor Inhibition.*—The suggestions put forth under this heading are tentative, for experimental evidence is lacking to a considerable extent. Nevertheless there are some analogies to cardiac inhibition, and this seems to be the proper place to discuss them. The general conception that stimulation of a nerve connected with a muscle must cause contraction of that muscle encounters an exception in the case of vagal stimulation, which does not cause stoppage of the heart in systole with contraction of the cardiac muscle, but in diastole with relaxation of the muscle—just the opposite condition.

Stimulation of the vaso-constrictor nerves causes contraction of the muscle cells in the walls of the vessel which they supply. The constrictors are also probably concerned in maintaining the tone of the vessel. Stimulation of the vaso-dilators causes dilatation of the wall of the vessels which they innervate. The two kinds of nerve fibres are antagonistic to each other (as are the cardiac accelerator and inhibitory fibres); moreover, both kinds of fibres may occur in the same nerve trunk, and an effect in a given instance will probably depend upon the relative proportion of the kind of fibres present and their susceptibility to stimuli.

One hypothesis that quite naturally suggests itself is that the vaso-dilator fibres inhibit the tonic action of the vaso-constrictors. The difficulty, however, is encountered that the vessels of any organ are dilated to a greater extent by excitation of the vaso-dilators than they are by paralysis of the vaso-constrictors. In spite of the destruction of the vaso-constrictor nerves, the vessels after a period recover their tone. That the tone is not even for a time abolished completely is shown by the fact that a local dilatation can be produced by certain chemical irritants. Thus it seems evident that some peripheral mechanism exists, a mechanism which, it is true, can be paralyzed by the local application of such a drug as chloroform.

Hill suggests that it is highly probable that the vascular muscles are maintained in a state of tone by the tension of the blood within the vessels. This would be, as he suggests, in close analogy with the fact that the heart is excited to contraction by a rise of internal tension. If this hypothesis be accepted, it may then be supposed that the vaso-constrictor nerves increase the excitability of the vascular muscle to the stimulus of blood tension, while the vaso-dilator nerves diminish the excitability. The vaso-dilator fibres would thus be brought into analogy with the cardio-inhibitory nerves. These lessen the irritability of the heart toward the intracardiac tension (Hill and Barnard, *Jour. Physiol.*, 1897) and relax the cardiac muscle.

On this hypothesis, section of the vaso-constrictor nerves abolishes that tonic condition of exalted excitability to internal tension which is maintained by the vaso-motor centre. It does not, however, entirely destroy the excitability of the vascular muscle to tension, and with time the tone is fully restored. On the other hand, the vaso-dilator influence completely relaxes the muscle by altogether inhibiting its excitability to tension. It is conceivable that the quality as well as the tension of the blood may be the exciting cause of vascular tone. An increase in the alkalinity of the blood favors the development of tone. Certain glands, such as the suprarenals, appear to secrete a material into the blood which produces vascular contraction (Hill).

Inhibition of Secretions.—Secretion, in general, is due to two factors: to the blood circulating through the glands, modified to a certain extent by such conditions as blood pressure, rate of flow, etc.; and to the presence of secretory nerve fibres, although the latter have not been satisfactorily demonstrated in all cases. The blood brings to the gland material which, after a certain amount of elaboration, forms a greater or less portion of the secretion.

Assuming that there is some reason in what has been stated regarding vaso-motor inhibition, there seems to be a correlative connection between it and the process of secretion. This, taken in connection with the action of the secretory nerves, means that the changes going on in the gland are influenced by a nervous mechanism which has the power of regulating the chemical activity of the gland, and at times may totally suppress the secretion.

Positive evidence regarding the inhibition of glandular secretions is lacking to a large extent, but the view above set forth provisionally seems to have some connection with the general subject of inhibition. The influences of some drugs and of psychical or emotional phenomena also have a bearing in this direction, especially with regard to the salivary glands.

Inhibition of the Movements of the Stomach.—Openchowski, in 1883, found that the cardiac orifice of the stomach could be dilated by stimulating a nerve at the lower portion of the œsophagus. He called it "nervus dilatator cardiæ." It was found that this nerve was formed by the union of strands from the two vagi. Langley, in 1898, carried the investigation further. His method was to inject curare into a vein, in order to paralyze the motor nerve endings in the striated muscle of the œsophagus. Atropine sulphate was also injected into the vein, in order to weaken the œsophageal motor nerve fibres and to paralyze the inhibitory nerve fibres of the heart. Stimulation of the vagus under these conditions produced inhibition or dilatation of the cardiac sphincter of the stomach. When the above-mentioned drugs were not injected or if atropine alone was used, the experiment failed. The body of the stomach, also the pyloric sphincter, gave variable results. Occasionally there was inhibition (relaxation) of the fundus and of the whole stomach, but this result was by no means constant.

Inhibition of the Movements of the Intestines.—The discordant results obtained as to whether the vagus is a motor or inhibitory nerve to the intestines are probably due to the influence of various disturbing factors, among which may be mentioned the influence of anæsthetics and the exposure and handling of the intestines, with the circulatory changes thereby induced. More important than these, according to Starling, are the inhibitory influences originating either in the higher parts of the intestine and travelling down the intestinal wall, or started by any sensory stimulation of the intestine itself and transmitted reflexly through the cord. Such influences may largely be cut out by cutting both splanchnics and avoiding any lesion above the point observed.

If these precautions be taken, stimulation of the vagus in the neck, after paralysis of the cardio-inhibitory fibres by means of atropine, will always produce an effect upon the intestinal movements; the effect, which may be little marked at first but increases with each succeeding stimulation, is twofold: (1) an inhibition with very short latent period (less than one second), leading to the dropping of one or two beats; and (2) an augmentation of the rhythmic contractions, which gradually develops after the lapse of from ten to thirty seconds, and lasts for some length of time after the cessation of the stimulus. The vagus effect may come on simultaneously at all points of the small intestine, and is not abolished by ligaturing the second part of the duodenum or the upper part of the jejunum. The vagus fibres must therefore reach the intestine at all points, and do not run down from the stomach or duodenum between the two coats (Starling).

Inhibition of Reflex.—As is well known to physiologists, some reflexes may be controlled or at times altogether prevented. The most favorable conditions for a reflex involve the activity of those parts only which form the reflex arc—a sensory surface, afferent nerve, centre, efferent nerve, and the part to which the latter is distributed (muscle or gland). Involvement of any other portion of the central nervous system usually hinders a purely reflex act. Examples of reflex acts are too familiar to make it necessary to mention them. It is a well-known fact that a cough or sneeze may be checked, although the desire to perform the act is wellnigh irresistible. The cerebrum probably excites the greatest inhibitory action over reflexes. The case of Cranmer, the martyr, may be cited as an example. In spite of

the natural tendency, he held his hand in the fire until it was consumed, thus inhibiting the power of reflex.

Inhibition Referred to the Cerebral Cortex.—The power exerted by the cerebrum in inhibiting reflexes, and its action upon the cardio-inhibitory centre, have already been referred to. The cortex is known to possess the power of originating movements; it has also, perhaps, a function no less important, namely, that of inhibiting movement. The restlessness of lunatics, with lack of mental balance, and the restlessness of dogs which have been deprived of their cerebral hemispheres, as shown by the experiments of Goltz, may be due to the diminution or loss of this inhibitory function. The condition of hypnosis may be the result of, or associated with, a temporary total deprivation of volition, due to an increase of the inhibitory function, as suggested by Schäfer.

Bubnoff and Heidenhain (1881) showed that inhibition was an active function of the cortex. They occasionally got arrest of action after weak excitation.

Sherrington (1893) has shown that electrical excitation of certain parts of the cortex may not only, as has long been known, produce contraction of definite muscles, but that simultaneously inhibition of tonically contracted antagonists may also be brought about. It is probable that the inhibitory action, whatever it may be, is exerted upon the lower nerve centres in the cord and bulb (Schäfer).

Inhibition of Pain.—Assuming that pain may actually be inhibited, the sensory side of the nervous system and the cerebrum would represent the parts involved. Kant has described that he learned to inhibit the pains of his gouty attacks. Other instances may be found, but one of the most interesting cases is that of a so-called "painless man," who had been on exhibition in various shows as "the human pin cushion." He was under the observation of, and his case described by, Witmer (1897, "Twentieth Century Practice of Medicine"): "He could be cut with a knife, or stuck with pins and needles, without showing the slightest sign of pain. I have known him to hold a red-hot coin in his hand without wincing, until it had burnt itself deep into the flesh. It is impossible to say positively whether this subject inhibited the expression of pain, or whether he inhibited the pain itself. He said he felt pain on ordinary occasions, when he had not made up his mind to be insensible to pain; but he reported that when once he had decided not to feel the pain of the stimulus, the pain was no longer felt. There were areas of the skin which he could not render insensible to pain. I am inclined to believe he inhibited the sensation of pain and not its external manifestations."

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INNERVATION means the nerve supply and nerve control of some part or other of the organism. This definition embraces every kind of nerve influence and includes therefore the exciting as well as the inhibitory action on the part concerned. It moreover includes the activity of all those sensory (afferent) nerves or nerve apparatuses that serve to transmit sensory impulses from the organ concerned to nerve centers of both the peripheral (sympathetic) and the central nervous systems. If, however, any nerve or nerve apparatus, although situated in the immediate vicinity of a given organ or even within the organ itself, has no connection with the elements of the same, and therefore exerts no influence whatever on its function, such nerve or nerve apparatus must be excluded from the "innervation" of this organ. Usually when we speak of the innervation of an organ we include the nerve control of all its tissues. For instance, innervation of the small intestine means the nerve control over its glands, muscles, blood-vessels, and connective tissue, as well as that nerve supply which conveys sensory impressions from the intestine to nerve centres of the peripheral, and central nervous systems. If we speak of the "innervation" of a muscle the term should include the nerve control over its blood-vessels and its sensory supply, although often the motor action on the muscle fibre alone is meant.

Not only the nerves and nerve apparatus directly connected with the part or organ concerned should be included in the definition of its innervation, but also those connected with it more remotely, as long as they have any control over it. For instance, the arm area of the cerebral cortex belongs within the domain of the innervation of the arm, although when speaking of the latter we more frequently have in mind the peripheral nerves and nerve apparatus connected with it.

B. Onuf (Onufrowicz).

I. INSANITY.—(Synonyms: Eng., Mental alienation, lunacy, aberration; Lat., *Insania, insanitas*, from *insanus*, unsound; Fr., *folie, insanité de l'esprit, aliénation mentale;* Ital., *insania, follia, alienazione mentale;* Sp., *insania, locura;* Ger., *Irrsinn, Irresinn, Wahnsinn, Verrücktheit.*)

Definition.—An actual definition of the term "insanity" is seldom found in recent works on psychiatry. The reason for this is, as Tuke* explains: that it is impossible to compass the multitudinous phases of mental disease under one rigid formula. Spitzka has endeavored to cover the ground in a "definition" one hundred and twenty words in length, but admits the futility of any definition except perhaps for medico-legal purposes. Even in the courts, however, a definition of the term is nowadays seldom called for, as most alienists have come to regard it as unwise and prejudicial to their reputation to attempt it. Chapin gives the definition of insanity as "That mental condition characterized by a prolonged change in the usual manner of thinking, acting, and feeling, the result of disease or mental degeneration." This like all other definitions of insanity is not unassailable, but is sufficiently comprehensive for a medico-legal opinion, is easily understood, and is more serviceable than most of the multitude of definitions that were once in vogue.

For further consideration of the subject the reader is referred to the chapters on the *Diagnosis* and the *Medico-Legal Aspects of Insanity* below. *H. R. S.*

II. INSANITY: CLASSIFICATION OF MENTAL DISEASES.—In the sense in which the term is generally used by writers on scientific subjects classification not only implies that the division shall be logical and the characteristics by which it is determined natural, but also at the same time presupposes the existence in the mind of the writer of a specific purpose. (See "Classification." Baldwin's "Dictionary of Psychology.")

Any attempt to classify mental diseases, *i.e.*, to group together those forms which have certain common and distinguishing characteristics, must necessarily be modified by, and to a large extent depend upon, the author's conception of what does and what does not constitute insanity, since it is obvious that the term is used in a purely conventional sense and does not admit of exact definition any more than do the common terms health or disease. Such being the case, it is plain that fundamental distinctions in psychiatry do not exist. The history of medicine as well as that of other sciences shows clearly that the effort to establish artificial distinctions may be fatally antagonistic to the spirit essential for the sound development of scientific investigation and the further advancement of knowledge. As at present we are quite unable

* See Tuke's "Dictionary of Psychological Medicine."

to establish any generic distinctions between the various forms of alienation, it is hardly possible to emphasize too strongly the importance of the fact that the aim of classification should be merely "to facilitate the complete and systematic survey" of the various forms of insanity. Any scientific classification is essentially a generalization. This predicates an accurate knowledge of the individual phenomena whose common as well as distinguishing characteristics are to be compared. As the paucity of facts in the clinical study of psychiatry does not permit the term to be used in any but a conventional sense, it is questionable whether the retention of the word classification in psychiatrical nomenclature is desirable, and perhaps it might be better at present to substitute for it such expressions as "grouping of," or "general description of," mental disorders. Such terms would certainly be less definite and therefore less apt to lead to confusion.

The efforts to group together the various forms of alienation often have a real, although relative and tentative value. Work of this kind, if well done, has the temporary advantage of formulating and crystallizing opinion, but the relative success of each individual effort in this direction must necessarily be inversely proportional to the rate of progress in psychiatry, inasmuch as the true value of any grouping of the various symptom complexes is commensurate with the stimulus given to further investigation, and the greater the stimulus the sooner does the work of any given author become obsolete.

In all attempts at classification the standpoints to be taken into consideration are four in number: (1) etiological; (2) psychological; (3) clinical; (4) pathological. The relative value of these determining factors in any so-called classification is essentially conditioned by the aim of each individual writer. Unfortunately, some authorities, with a singular disregard for accuracy of expression, have attempted to classify forms of alienation on such a basis that only one or two of these factors have been considered. As a result of this error there have been so-called etiological classifications, clinical classifications, etc. It may be justly said that attempts to classify mental disorders on such a basis have almost invariably shown a disregard of the fundamental postulate that every scientific classification necessitates a consideration of all the known factors which enter into the study of the natural history of a disease.

(1) With our present meagre knowledge the etiology of alienation can hardly be considered a prominent factor in the grouping of mental disorders. Unfortunately, alienists have frequently shown a tendency to be satisfied with the statement of such general causes as are commonly enumerated under the head of etiology. The clinician now realizes fully the necessity for substituting for these general descriptions more definite and exact knowledge. No reader can have failed to be impressed with the fact that within the past decade writers have begun to avoid such indefinite expressions as "lack of proper nutrition," "proneness to alcoholic indulgence," "unsuitable hygiene," "bad family history," etc., and to adopt a nomenclature which has more in common with the phraseology used in the general medical clinic. It is only necessary to refer to the recent studies in which attempts have been made to determine the relationship of alcoholism and syphilis to general paresis, of the puerperal condition to the various mental disturbances connected with it, or of the effects of previous injury to the subsequent traumatic psychoses, to show that efforts in the right direction are being made to determine more specifically the connection between cause and effect. In a study of the etiology of mental disorders investigators are confronted by two classes of difficulties. It is not only necessary to isolate the causative factor in any form of alienation but the individual reaction to this cause must be explained. Writers who have failed to appreciate the necessity of taking into account this personal equation have only added materially to the confusion that already exists in clinical psychiatry. This point has been emphasized of late by the recent studies of Binswanger and others upon the etiology of the acute psychoses. Although the immediate results so far are negative, such work cannot fail to be of signal advantage in forming a basis for further investigation. As is well known, many attempts have recently been made, particularly by the Italians and Germans, to show that a definite causal relationship exists between certain clinical forms of the acute psychoses and bacteria or their toxins. Even if the truth of these general propositions were established it would still remain for the clinician to explain why the brain of one individual was a *locus minoris resistentiæ* for the poison, while that of another person was unaffected by it. Until these problems are solved the generalization essential for every classification remains impossible, and the alienist must frequently be embarrassed by the necessity of admitting that a single pathogenesis may make itself manifest by a great variety of symptoms, and that the converse of the proposition is no less true. It is hardly necessary to emphasize the fact that with our present knowledge heredity has no claim to be considered a prominent factor in any scheme of classification; and the same holds true in regard to the relative frequency of mental disorders at different epochs of life. Thus, although it is doubtless useful to note the fact that certain forms of alienation would seem to be more common at the time of puberty, of the menopause or vice versa, to go further and to attribute so much importance to an observation of this character as to suggest it as a possible basis for generalizations would be as ill-advised as the belief that our actual knowledge of measles is made greater by classifying it as one of the diseases of childhood.

(2) The attempt to analyze the mental symptoms of the insane upon a psychologic basis, although of some value, is of greater interest to the psychologist than to the alienist. The points of view of the two observers are essentially different. Those who are interested in this method of study are advised to consult the standard works on psychology or books written on the line of that of Störring in which the relative importance of the psychological phenomena is indicated ("Vorlesungen über Psychopathologie," 1900).

(3) Although pathologists have actually demonstrated that out of all the cases of mental disease there are only a few in which lesions cannot be definitely demonstrated in the central nervous system, the relation of these structural changes to the symptoms of the disease is too indefinite to afford a basis of classification. Moreover, since none of the changes occurring in the central nervous system in the insane are distinctive, nothing has been gained from the numerous attempts to differentiate between the forms of alienation associated with or those accompanied by actual demonstrable changes in the brain. A moderate degree of familiarity with psychiatrical literature is sufficient to convince the reader that the study of mental diseases has advanced too far for a grouping on this basis to have any present value. On the other hand, too little progress has been made in estimating the distinctive character of the lesions to warrant the building up of any systematized study upon so weak a foundation.

(4) So-called clinical classifications are of little value, and one cannot but agree with Bevan Lewis and others that a disproportionate amount of attention has been given to this method of study. It would be impossible within the present limits to refer to even the more recent attempts that have been made by alienists to divide into groups the various clinical pictures. Unquestionably within the last decade the most suggestive and stimulating efforts in this line have been made by Wernicke and Kraepelin. Notwithstanding the fact that the points of view of these two authorities are essentially different, many new paths in clinical psychiatry have been opened up by their efforts.

Wernicke has assumed that the hypothesis based upon the localization of the physiological functions of the cerebral cortex is applicable to the problems of clinical psychiatry. He believes that psychical symptoms can be analyzed by a method analogous to the one employed

in his well-known study of disturbances of speech. Disturbances of the intellectual activities are conceived of as localized disturbances and as due to derangements of the associative mechanism. Variations from the normal in the associative mechanism of the brain may be looked upon merely as disturbances of action. The scheme adopted by Wernicke is as follows: The memory picture is formed in the cortex of the projection field and is there primarily identified. The simple sense perceptions awaken a secondarily identified outgoing perception A. AZ represents the intrapsychic associative mechanism in which the secondary identification takes place. Z is the area where the secondary identification gives rise to the outgoing impulse. AZm represents the psychomotor projection field of the cortex. According to this conception the mechanism of the psychical processes may be represented by the scheme s A Z m. The psychic sensory disturbances (sA) are comparable with the anæsthesias, paræsthesias, and hyperæsthesias; the intrapsychic disturbances (AZ) with loss, disturbance, and excess of function, respectively; the psychomotor disturbances of function (Zm) with the akineses, parakineses, and hyperkineses.

Consciousness is a function of the associative mechanism and may be considered in its threefold relationship to the outer world, the body and self-allopsychic, somatopsychic, and autopsychic. Disturbances may occur in any one of these realms either singly or combined. These fundamental considerations are developed at length to form a basis for the clinical observations. (See reviews by C. Winkler: *Centralbl. f. Nervenkrankheiten und Psychiatrie*, xxxiii., p. 569; also Worcester: *American Journal of Insanity*, vol. lvii., No. 4.)

Kraepelin's grouping* is based on the principle that connected with the origin, development, and termination of disease every factor must be considered. In cases in which nothing definite is known in regard to the etiology not only the whole clinical course is taken into account, but the deductions which are important for prognosis should also be utilized in the attempt to differentiate one malady from another. Kraepelin first considers the forms of alienation which are due to external causes. Among these are classed the mental disturbances following infectious diseases, the so-called exhaustive psychoses, in so far as they are due to severe physical derangement, and finally, the poisonings. Contrasted with the poisonings due to external agencies are the auto-intoxications. Of these we have definite knowledge in regard to one only, viz., mental disturbances associated with diseases of the thyroid gland. Kraepelin holds that there are reasons for believing that dementia præcox and general paresis may also sooner or later be grouped with the diseases originating in auto-intoxication. Next come the insanities associated with organic diseases of the brain. The insanities of senile involution and those in which there is marked tendency toward psychical impairment—paranoia and the maniacal-depressive insanity (see *Mania*)—are grouped separately. Then follow the general neuroses, the epileptiform and hysterical insanities closely connected with these, the psychopathic conditions, and, last of all, those conditions which are characterized by inhibition during the development of the psychical functions, namely, idiocy and imbecility.

For further information on the subject of classification the reader is referred to the various text-books on insanity as well as to the works mentioned below.

Stewart Paton.

*Table of Kraepelin's Latest Classification of the Forms of Insanity. (Sixth Edition.)

Infectious insanity.
- A. Febrile delirium.
- B. Infectious delirium.
- C. Infectious states of weakness.

Exhaustive insanity.
- A. Collapse delirium.
- B. Acute confusional insanity (amentia).
- C. Chronic nervous exhaustion.

Poisoning.
- 1. Acute poisoning.
- 2. Chronic poisoning.
  - A. Alcoholism.
  - B. Morphinism.
  - C. Cocainism.

Thyreogenic insanity.
- A. Myxœdematous insanity.
- B. Cretinism.

Dementia precox.
- Hebephrenic forms.
- Katatonic forms.
- Paranoid forms.

Dementia paralytica (paresis).
- Depressive form.
- Expansive form.
- Agitated form.
- Demented form.

Insanity in cerebral diseases.
- General diseases (cortical gliosis, diffuse sclerosis, late hereditary syphilis, arteriosclerotic disease, perivascular gliosis, subcortical encephalitis, multiple sclerosis).
- Circumscribed diseases (tumor, abscess, hemorrhage, embolism, thrombosis, injury).

Insanity of the age of involution.
- A. Melancholia.
- B. Presenile delusions of prejudice.
- C. Senile dementia.

Manic depressive insanity.
- Maniacal states.
- Depressive states.
- Mixed states.

Paranoia.

General neurosis.
- A. Epileptic insanity.
- B. Hysterical insanity.
- C. Fright neurosis.

Psychopathic states (degenerative insanity).
- A. Constitutional morbid peculiarities of character.
- B. Imperative insanity (imperative ideas, phobias, hypochondria, folie du doute, mysophobia).
- C. Impulsive insanity (pyromania, kleptomania, homicidal mania).
- D. Sexual perversion.

Defective psychical development.
- A. Imbecility (moral weakness).
- B. Idiocy.

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III. INSANITY: GENERAL ETIOLOGY.—In considering the etiology of a given case of insanity, only too often do we mingle cause and effect, thereby confusing ourselves and spreading false impressions among the laity. It is a daily occurrence to hear both the physician and the family speaking of the cessation of the menses as the actual cause of the alienation of some young woman, whereas in reality such cessation is only one of many somatic symptoms that may accompany the mental affection, the psychical and bodily manifestations proceeding *pari passu* under a general storm-cloud, that involves every cell and fibre of the body in varying degree. Surely then we should look deeper before ascribing to a single minor physical symptom the dignity of the entire upheaval. It might be approaching a little nearer to the truth to attribute such disturbances to the hæmic depravity which is so frequently present in such instances, but how much better to explore more fully the, now hidden, pathogenic fields that induce the anæmia itself.

The etiology of mental affections in very numerous instances is obscure, reaching back through the protoplasm of the fœtus and the tissues of the mother and father, to those of preceding generations unto the third and fourth degree—and even beyond. Such predisposing causes do not, however, exist in each and every instance of alienation. An individual starting with a healthy mind in a healthy body may also become the victim of a mental disturbance should he violate the laws of nature to such a degree as to overset the nervous equilibrium, or should he have the misfortune to meet with a cerebral trauma, or to admit into his system a toxin, be it of syphilis or of some acute disease, in sufficient quantities to overcome the normal tissue resistance.

Again, in another series of cases, persons who have inherited only a moderate degree of stability, but who, owing to favorable environment and education, have

been able to pass successfully through the minor trials of the struggle for existence which are common to all mankind, may nevertheless fall victims to mental disturbances when some unusual stress is laid upon them, either in the way of intense and prolonged intellectual strain, a shock, corporeal or psychical, as a result of tissue changes induced by an acute toxæmia or prolonged cachexia.

Briefly, then, it may be said that the main causes of insanity are twofold—direct or indirect. In many instances these may be and frequently are commingled, rendering a clean-cut differential etiology difficult and sometimes impossible to determine.

Inasmuch as the far-reaching effects of neuropathic ancestry in its widest sense are, probably, of greater importance than the direct causes of vesaniæ, we will first consider the former, remembering always that the two are very frequently blended in the same individual.

I. Predisposing Causes.

Heredity.—The carrying-over from an ascendant to a descendant of the marks of a corporeal degeneration, such as webbed fingers or toes, or a deformed hard palate, are readily recognized and termed a stigma of degeneration. Were the brand marks of mental infirmity as clearly defined, much difficulty would be spared the alienist in the comprehension of mental deficiencies. Unfortunately such is not the case. For although the grosser defects of the mind, as they exist in the idiot and the lower grades of imbecility, are as unmistakable as those we are apt to regard as more strictly corporeal, the gradations between the mental level of the hopeless imbecile up to that of normal man are innumerable, and when these deficiencies appear, for example, merely in a lowered standard of ethical conduct, in a passionate disposition, or in an inability to reason quite as logically as the majority of mankind upon an abstruse subject, one can readily see how extremely difficult it is for the physician to pronounce definitely upon the mental condition of a person who shows such slight departures from normal mentalization.

Statistics of *heredity* among the insane differ according to the locality from which they are taken—varying from ten to ninety per cent. Much depends upon the nationality and consanguinity of a community, as well as certain local conditions, as, for instance, the prevalence of drunkenness, of an insufficient or improper quality of the food supply, of syphilis, of extremes of heat and cold, and other changing factors.

Except in rare instances there is no direct inheritance of insanity—that is to say, the children are not born insane; it is only that the protoplasm is tainted with seeds that, under favorable circumstances, may at some future time grow and bear blighted fruit in the form of a psychosis. Under proper precautious in the way of education and environment such a development may not occur at all, and the man or woman may pass through life with his or her mental faculties performing their functions in an average normal manner.

In fact, in mental disorders we have an heredity analogous to that of tuberculosis. The child of consumptive parents does not necessarily develop the disease, but if exposed to injurious surroundings which lower the general vitality, as insufficient breathing space tainted with the effluvia of human lung exhalations, it falls a victim to the disease more readily than one who has inherited more resistant tissues. In the psychoneurotic, as generation succeeds generation and there is no admixture of sounder blood strains, the tendency toward imperfect mental development becomes more and more accentuated, psychical maladies in the family become ever more frequent, until the lowest forms of mental infirmity appear and the house becomes extinct. An admixture of purer blood always has the tendency to correct both mental and psychical deficiencies and to induce a return to the standard level. When both mother and father are defective mentally, especially when there is consanguinity, the prospects for a perfect mentality in the children are ominous.

There is a curious law of inheritance which it is difficult satisfactorily to explain, to wit, the passing over by a mental disorder of the second generation and its reappearance in the third—the so-called *atavismus.* Again, we frequently see insanity in a collateral progenitor—an aunt or uncle for example—reappear in the nephew or niece, though the father or mother may have shown no tendency thereto. Only rarely, however, does the same form of psychosis reappear in the children as existed in the forebears direct or indirect. As a rule transmutations take place, and a state of pathological depression in an ascendant may develop as a morbid excitement or early dementia in the offspring of the house.

Exceptions to this alteration of the character of the alienation are now and then noted. I have met with a paranoia which had developed through three successive generations, and among the frequent periodic insanities the identical form of malady may appear for generation after generation. In these instances it is always probable that the psychosis will come on at an earlier and earlier age until some of the grave forms of pubescent or adolescent insanity appear—in other words, the vital protoplasm becomes lower and lower and less capable of standing the strains of education as well as the duties and cares of daily life.

Suicide.—A suicidal tendency may appear in neuropathic families as the equivalent of a psychosis or replace it. Usually, however, there will have been some previous indication of mental perversion preceding the event, and most often this has taken the form of a more or less pronounced melancholia. Not long ago I treated a neurotic individual whose three aunts, an uncle, and father had all committed suicide at about the same age, and in the generations back were histories of neuroses, deaf-mutism, and individual peculiarities, with tendencies to melancholia. The descendants of hysterical, epileptic, neurasthenic, and eccentric parents always show a larger proportion of examples of insanity than those with a good family history. The former start in life with a defective cytoplasm, and when the environment is suitable the soil produces a crop of poisonous weeds. Such nervously deficient parents are apt to have children who are degenerates in the matter of moral tone, eccentric beings standing apart from the mass of their fellows, and who at a later age show sexual perversions, criminal propensities, and are in constant conflict with the existing order of things, and under any unusual strain become victims of a psychosis.

Alcohol and Heredity.—Perhaps the most frequent cause of mental degeneration in the descendant is alcoholism on the part of one or both parents. The abuse of alcohol induces definite and pronounced tissue alterations, not confined to but most noticeable in the nervous and vascular systems. As a result the children of such progenitors are ever prone to epilepsy, hysteria, and grave mental maladies, and should the tendency increase in succeeding generations to a pronounced degree, the family soon dies out. Drunkenness on the part of both parents at the moment of copulation is one of the most certain causes of idiocy.

In the family of a drunkard, where there are a number of children, it is often observed that the first ones are mentally sound, while the later arrivals, after the drink habit has been confirmed, are less and less apt, and if the abuse becomes aggravated the youngest members of the family are not merely deficient in mental and physical capacity, but are actually imbeciles or idiots.

There are many notable exceptions to this rule. Owing to especial or exceptional circumstances, one child may stand forth prominently in the family by reason of his mental endowments, while all the others may be defective. As Griesinger long ago observed, genius and idiocy go hand-in-hand, and after all genius is but a one-sided psychical development, as is notably illustrated in the family history of the poet Byron, with his insane and suicidal ancestry, and his own tendency toward psychopathy.

The cheapening and accessibility of spirituous liquors in recent times are undoubtedly largely responsible for the modern increase in insanity, and should their sale remain unrestricted by suitable legislation, mainly by increasing the price, by taxation, to such a degree as to render the abuse impossible by the average man, we may in the future expect to see a still more alarming augmentation of the lunacy evil. Unfortunately, also other tissue-degrading drugs that act practically in the same way as the alcohols have in recent times been brought into extensive use. Degrade the vitality of the cell protoplasm of the ancestor, and as a logical sequence that of the descendant must also suffer—a dictum that applies not only to the effects of drugs, but also to those of syphilis, tuberculosis, severe febrile affections, sexual, corporeal, as well as psychical excesses, and a whole host of other debilitating influences.

In the psychiatrical clinic, one soon learns to recognize the hereditary degenerative forms of insanity by the presence of certain characteristics. Thus we note the frequent onset at the time of adolescence, the periodical return of the psychosis, the tendency to impulsive acts or to stupor, the outbreaks of active insanity when any unusual strain, as in childbirth, is laid upon the person, or even when the system is deranged by a minor physiological function, as the menses. These factors in the hereditarily burdened only too often suffice to bring about abnormal depression, hallucinatory excitement, profound stupor, or alternations of the one with the other.

Education.—This term as used here in its broader sense refers not alone to book-learning or technical training, but to all the multitudinous and varied influences that surround the child *ab incunabulis*. Almost from birth the infant begins to receive and acquire impressions of various kinds, their complexity increasing as time goes on. In the earlier years of childhood the growing mind and body are susceptible to influences that later on would make no impression upon the organism. The judgment is not formed, reasoning is carried on in an imperfect manner; yet the soil is fertile and easily cultivated, and the impressions received are much more vivid than at a later date. According to the tilling it receives the ground may bear either weeds or precious grain.

Except in rare instances, in which hereditary tendencies are too strong to be successfully combated, if the young child is ruled with a systematic, firm, though gentle hand; if natural tendencies to evil are repressed by wise correction and proper reward, while at the same time suitable attention is paid to diet and hygiene, there can be no doubt that by the indrilling of correct principles a great deal may be done to overcome hereditary neuropathic tendencies. But that education may have a lasting effect, these children must be taken from the time that the earliest permanent impressions are recorded on their brain cells, and such surveillance must not cease until adolescence is attained.

On the other hand, if a child, the offspring of insane or neurotic parents, be submitted to the usual course of training; if, as not infrequently happens, especially among the poorer classes, he be allowed to grow up with little or no moral or home teaching; if he be subjected to the brutalities of an intemperate father or to the perpetual irritation arising from a fretful, ill-tempered, or neurotic mother, the result can readily be prophesied; the force of constant surrounding and example must inevitably obtain. To these perverting influences upon the mind are often added an unsuitable diet, a total lack of hygiene, ill-ventilated rooms, and insufficient clothing.

In the case of those of better social standing other factors have to be considered. Many hereditarily unstable children are precocious, impulsive, irritable, and difficult to control. Too often the weak mother either neglects them or humors and pampers them in every way, and yields even when the exercise of a firm hand is of the utmost importance. As a natural result the children become wayward, emotional, without will power, and as they advance in years give way to license and self-indulgence. After a course of excesses in social pleasures, or in venere et baccho, which their undeveloped nervous systems are unable to withstand, many of these unstable minds fall by the wayside during adolescence.

Furthermore, even although the neuropathic children may have received a good home training and have been taught to control their passions and instincts, when they arrive at the school age a new danger awaits them. One of the crimes of our American system of public school education is the grouping of large classes of children together with but little or no recognition of their natural individual mental capacity, physical vigor, or infirmities, and ancestral tendencies. The bright ones are incited to continuous effort by varied stimuli, the dullards are goaded to exertions beyond their capacity. Many of the children of highly neurotic parents are intelligent, but have little reserve force, and when this premature forcing of their intellectual powers is laid upon them, they respond for a time with all their ability, but at the cost of their physical health. Should the danger signals, such as listlessness, irritability, and emotional outbursts be overlooked or misinterpreted, for a time the victims may still answer to additional stimuli, supplied by the vanity of parents and teachers, but sooner or later they collapse and become mental and physical wrecks. Recuperation in such instances is most difficult, and no amount of care on the part of physician or parents can fully overcome the lost freshness of psychic vigor. In later life they become neurasthenics, weak and deficient in nerve force, or fall a ready prey to some of the many forms of psychosis upon a constitutional basis.

Give the children plenty of open-air amusements with playmates of their own age, under suitable supervision; let them have plenty of food, not too stimulating; give them few hours of confinement in close school-rooms, and psychoneurotic ailments will much decrease in frequency. On the other hand, the running wild on the streets, the companionship of vicious children of older age, the forcing of the sexual proclivities in unnatural ways, by bad example, all tend to the evolution of a morbid nervous system.

The close crowding into cities, replete with all forms of vice, in recent years has also had much to do with the more frequent development of asthenic nerves and criminality.

Masturbation about the age of puberty is frequent among the hereditarily weak; if habitually practised for any length of time it tends to induce anæmic and neurasthenic conditions. Although rarely the sole direct cause of alienation, its effects upon the undeveloped nervous system are always debilitating. Again, in addition to the physical harm there is the bad moral influence, the feeling of guilt, the constant fear of discovery, the tendency to avoid the society of others, to brooding, and to the neglect of wholesome exercise.

Civilization.—It is an undoubted fact that insanity is far more frequent and shows a steadier increase in civilized than in uncivilized countries. In England one individual in every three hundred is insane, and in the more densely populated States of the Union, as in New York, very similar figures are reached. The life of the savage is free from the cares that weigh upon the educated man; he takes no thought for the morrow, his necessities are not complex, and he is free from the multitudinous petty worries that besiege the civilization of the present era. Unless in contact with the white man he is not syphilized, alcoholized, or subject to the ravages of tuberculosis; he lives a life of freedom in the open air, his actual wants are few; he has no intellectual excesses. That civilized man is provided with better clothing, that he has more constant supplies of food, and in the cold seasons enjoys better hygienic surroundings can only to a small extent make up for the increased mental strain and the various detrimental physical conditions to which he is exposed.

Three main factors contribute to the increase in insanity among civilized nations—the constant struggle for a competence, which is daily growing more severe, the in-

creasing frequency of the abuse of alcohol, the spread of syphilis, all of which act with especial violence upon the brain of such individuals as are hereditary weaklings.

Nationality.—It is somewhat doubtful if under similar conditions individuals of one nationality are more susceptible to insanity than those of another, and in this connection statistics are often misleading. Thus, for example, we find that the association of cretinism and goitre with mental incapacity is very common in certain of the Swiss and Tyrolean valleys. But although in a general count of the entire population of these districts alienation would be considerably augmented, in other portions of the same country, not influenced by similar telluric conditions, there would be only the average number of insane. Under conditions in which the burden of life is brought to bear with unaccustomed violence upon the members of any race, as for instance the Irish who have emigrated to this country, or the Russian Jews who have been driven from their homes and obliged to start afresh in the world under unaccustomed conditions, the proportion of insane individuals is extremely high, though in their own land it may not be above the average.

In both of these races we may note an exception to the above general statement that the disposition to psychoses is about the same for the several races, in so far that with these there is a certain instability of the nerve elements that render them ready victims when the stress of life falls too heavily upon them. Again, our American negroes afford a striking example of the baneful results of altered conditions. Before the Civil War there were few or no psychoses among them, and such organic degenerative diseases as syphilitic insanity and dementia paralytica were practically unknown. To day in communities where many are collected, as in Washington or Baltimore, the percentage of insane negroes, not to mention idiots and imbeciles, is already fully up to that of the Caucasian races with whom they are associated, and bids fair to surpass it. This is largely owing to the spread of alcoholism and syphilis among the colored people, to the deleterious effects of bad hygiene and inferior food, and to an irregular mode of living, which has taken the place of the wholesome diet, the enforced regular habits, and the freedom from anxiety that belonged to slave life.

Climate and Seasons.—These are factors of very minor importance in the evolution of insanity. The harmful effects of heat in the South are more than counterbalanced by the more prevalent abuse of alcohol in colder regions. In a general insane asylum where the middle and lower classes of the population are received, a study of the records will show that a larger number of admissions in one year may occur during the winter, whereas in other years the same holds good for the spring, summer, or autumn. Hence one is obliged to conclude that the seasons have little to do with the evolution of insanity.

Gender.—In 48,587 admissions into the New York State hospitals there were 1,043, or two per cent., more insane men than women. Nor need the smallness of the difference surprise us much when we consider that the greater inclination in men toward the abuse of alcohol and the mental stress that falls upon the bread-winner are to some extent counterbalanced by the trying incidents of the puerperium, the climacteric, and the weight of family cares in the case of harassed housewives, whereas in single women the lack of natural sexual intercourse often predisposes to morbid psychical conditions. Hence in general it may be stated that the disposition toward insanity is about equal for the two sexes.

Religion.—While it is frequently true that certain sects, notably the Hebrew communities, show a higher percentage of alienated than others, it is probable that the faith of the insane person is not so often responsible as the repeated consanguineous intermarriages, particularly of neurotic strains, and to the fact that in past generations these people have been herded together in close and squalid habitations in crowded cities.

The duty, piety, abnegation of self to the needs of others, the raising of the moral and social tone, the trust in a hereafter taught by true religion, supply a strong prophylactic against, rather than a cause of alienation. It is a matter, however, of daily note that many unstable persons, when insanity is beginning, take a new and violent interest in prayer-meetings and missions, and that the mystic, erratic, evolutional paranoiac seizes upon the outward semblance of religion, not for its true intent, but as a stepping-stone in their perverted imaginings.

Civil State.—Experience has shown conclusively that among the unmarried the percentage of insane individuals is far larger than among the married. A partial explanation of this preponderance, however, may be found in the fact that many persons do not enter into the bonds of matrimony because they recognize their strong proclivities to the psychoses, and do not wish to continue a degenerate race.

The greater regularity of the sexual relations, the influence of home life, the better sanitation and better food that belong to the home are undoubted factors in lessening the frequency of mental troubles among the married. To counterbalance these to some extent are the increased duties and obligations in providing for the progeny, nor can it be doubted that the irritation of constant strife and vexation incident to unhappy marriages tends to disturb mental equilibrium.

Age.—It has been generally thought that three periods of life are particularly liable to outbreaks of nerve storms of variable violence: the time of the evolution of the sexual functions at puberty, the time of their retrocession (especially in women), and the years of senility. In the first two, besides the evolution and involution of the sexual apparatus, the growth and recession of certain tracts of the central nervous system no doubt play an important part. In the last period imperfections of the vascular apparatus are of especial moment. On the other hand, statistics of a large number of insane of all ages show that from puberty to the forty-fifth year there is a gradual increase in the number of the alienated, and that the wave crest of the psychoses is not at an early or late age, but in the later years of middle life; also that afterward there is a recession. Accordingly the three periods mentioned above are notable only by the character of the psychical disturbances that originate at these times.

About the seventeenth to the eighteenth year the intracortical association fibres reach their maximum development; nerve cells before inactive now come into function, the new adjustments of the neuron terminals affording paths of conduction that before this period were unavailable. As a result the mental development is now at its height, and the period of best attainment in both the intellectual and physical spheres is now beginning.

Should the brain organization be unstable, this rapid development may result in serious disturbances of the functional equilibrium, not alone of the nervous system but of the entire body, and a precocious senility may set in, accompanied by nerve storms of greater or less severity (excitement or depression), which end only with the death of the psyche, and the person becoming relegated to an intellectual plane lower than that of the beasts of the field. The depths of the psychic tumult may be increased and the subsequent dementia greatly augmented by the presence of constitutional or acquired vascular insufficiencies or degenerations. This oversetting of the intellectual equipoise may be promoted or greatly assisted by excesses, especially in alcohol, onanism, and venery, as well as by over-study without sufficient outdoor relaxation, to keep the body healthy.

Insanity in childhood is a rare phenomenon. It is true that there is such a thing as an insane baby, but the disturbance represents merely an impulsive rage. Later, as mental development proceeds, the forms of the psychoses become more diversified, and we may encounter impellent acts, mania, as well as melancholia, and in rare instances, in families with a luetic taint, even a form of dementia paralytica.

For the reasons above given the age of puberty is perhaps the most hazardous in life for the mental stability

of man or woman. While actual outbreaks of insanity are not nearly so frequent at this period as at some subsequent epochs, the groundwork is often laid for the later collapse. A sound education—using the term as meaning an efficient hygienic and moral training—begun in early childhood would go far to bring about the avoidance of the many factors (sexual, alcoholic, social excesses) that later lead to serious consequences.

It is somewhat difficult to determine the relative incidence of insanity in the sexes at the age of puberty. Krafft-Ebing states that females are more disposed than males on the ground that inheritance plays a greater rôle in the case of the former. Maclachlin, on the other hand, holds a diametrically opposite view, and his assertions are borne out by statistics from the immense material accumulated in the New York State asylums. In any case, however, the disproportion is not great.

Besides inheritance and excesses, especially onanism, other factors come into play as immediate evokers of alienation in youth. Of these the frequent anæmias and chlorosis, the confinement in close rooms at school, mental over-exertion, insufficient sleep, and lack of open-air exercise in cities, all claim their victims.

Insanity in both sexes is much more frequent from the eighteenth to the twentieth years than in earlier life. Indeed as adolescence approaches the tendency toward insanity increases and the maximum is reached only some years after its attainment.

As nearly all the pubescent and adolescent insane are the victims of inherited predisposition, the majority of the cases may be classified among the psychoses of the degenerate. They afford to the clinician certain characteristic stigmata, the principal of which are the frequent recurrences, automatism, and tendency to early dementia. Forms of depression (melancholia) are more frequent than those of exaltation. The former are chiefly of the periodic kind, sometimes simple, sometimes complex and alternating. It is not rare to find at this age the first phases of a circular insanity, or the germination of the seeds of a paranoia which is destined to come to maturity at a later period of life. The moral insanity of Pritchard is only a form of imbecility, the subjects in their one-sided character being not distantly related to the paranoiacs. Perhaps the most distinctive of the insanities of this period must be recognized in the hebephrenias (states of excitement) and katatonias (states of depression) of Kahlbaum, with the dementia præcox of which so much has lately been written by Kraepelin and others. Epileptic insanity and hysterical insanity are also common at this age.

Age of Maturity.—From the twentieth up to the fiftieth year there is a steady increase in the numbers of the insane, male and female, the acme being reached about the forty-fifth year.

All varieties of insanity are now prevalent, one only being distinctive—general paralysis of the insane. In the earlier periods of full manhood and womanhood the less complicated forms obtain, the melancholias predominating, the acute manias being next in frequency. Toward the end of the third decennary alcoholic and syphilitic psychoses outnumber the insanities connected with a constitutional basis, though it is reasonable to presume that inherited tendencies still play a principal part; besides, one can but suppose that the toxins of syphilis, as well as of alcohol, act with greater potency upon the man who has inherited psycho-corporeal infirmities than upon the individual whose nervous matter and blood-vessels are constitutionally sound. The dread disease of modern times, dementia paralytica, is ever growing in frequency, and though our home statistics (six to eight per cent.) do not show the enormous increase of the German and Austrian asylums (about thirty per cent. of the total admissions) the figures afford food for reflection. Syphilis is undoubtedly the most frequent predisposing element, being certain in at least fifty per cent., and probable in thirty per cent. more of the cases of progressive paralysis. Many other more common causes belonging to the prime of life and to our present civilization—the cares of the bread-winner, poverty, the burdens of a family, debilitating occupations, failures in business, mental over-strain in the great struggle for existence—all tend to overturn an already invalid brain.

Climacteric.—Whether we can speak of a true climacteric for the male is doubtful, but in any event this period does not come on until much later than in women, and is not accompanied by the same severe types of nervous and psychic disturbance. Between the fortieth and the fiftieth year a woman would appear to pass through the critical period of her mental life, not less than 19.8 per cent. out of 23,772 insane women falling victims within this period. Nor should such a result be unexpected. The fifth decade not only brings with it the gradual involution of the sexual functions with its concomitant emotional and nutritional disturbances, but also marks the beginning of senescence in the entire organism, the cerebrum included, and changes in the blood-vascular system, which from this time onward become more and more pronounced. As a natural consequence fatty alterations take place in the brain tissue, as is evidenced by the accumulation of metaplastic granules in the pyramidal cells. The evolution of productive creations of the intellect in some measure now comes to a standstill, though it does not cease altogether. The creative faculty is never so noticeable after the menopause as before that period.

The immediate factors in the causation of an insanity after the climacteric are often profuse menorrhagias or leucorrhœas which tend to induce anæmias and general depravity of the system. The sudden cessation of the menses not infrequently brings about a severe derangement of the entire system which may spend its force upon the nervous tissues, aggravating any psychical defect which may previously have been latent. Organic uterine disorders (myoma, carcinoma) do not seem to exert the same bad influence that follows the exhausting drain of a profuse, continued leucorrhœa or metrorrhagia.

Inherited predisposition still plays an important part in the psychoses of the climacteric, as is proved by the forms of mental disorder (periodic melancholias, paranoia).

The majority of women at this period of life suffer from more or less severe disturbances of various kinds. All physicians are familiar with the frequent "flushings," the feeling of fulness in the head, the roaring in the ears, the headaches, the disturbances of digestion and neuralgic pains, accompanied by a more or less marked loss of the intellectual stability, and a greater or less degree of thought inhibition. Many of these cases afford the clinical picture of various types of neurasthenia.

The graver disturbances of the psychic well-being are manifold, but do not attain to the dignity of any peculiar form of psychosis, unless the delirium of suspicion, which is quite common, may be classed as such. Many of these cases are so pronounced as to warrant the diagnosis of a paranoia. The patients show a hesitancy in both their thought and action; they are suspicious of every one and everything, although they may not reach the stage of actual delusions, and are usually able, if tactfully reasoned with, to correct their false impressions. Many of them stand on the border-line of sanity and insanity, and if carefully attended to and watched fully recover their mental stability. Of evil augury are the hallucinations of smell and hearing which usually mark the beginning of a chronic form of insanity.

Among the true psychoses the melancholias are the most frequent, and are ordinarily of the delusional resistive type. Some forms of periodic insanity, especially the depressive type, may begin at this epoch of life; circular psychoses also are occasionally encountered. What has just been said with regard to the suspicions which characterize some of the milder mental disturbances at the climacteric is equally true for the large number of cases of paranoia that reach a stage at this age that places the patients beyond the pale of society and necessitates confinement in an institution. Among sixty cases of menopause alienation Krafft-Ebing diagnosed forty-two

as belonging to one or the other of the various forms of paranoia, and although this proportion is not conceded by other observers, experience nevertheless shows a high percentage of persecutory systematized psychoses occurring at the climacteric. Cases of dementia paralytica, as well as those that run the course of a precocious senility, are now and then encountered.

The Insanities of Old Age.—For a man to have reached the age of sixty years and upward without the occurrence of an alienation of any kind is a distinct compliment to his ancestral protoplasm, and to a less extent to his own moral and hygienic habits. In advancing age the insanities of the psycho-degenerate have been left behind, except those that continue to recur periodically, and with whom the habit is retained. As a matter of fact, however, these are comparatively few in number, the most frequent being the periodic melancholia, a disorder that belongs not only to early but also to late life.

In the senium other factors arise. Comparatively few human beings wholly escape, in advanced life, some form of that involutive change in the cardio-vascular apparatus that we designate as arteriosclerosis.

These degenerative states of the arteries (which are also met with in the veins though in a less marked degree) affect mainly the intima and muscular layer of the vessel, and with the exception of one form bring about a certain diminution of calibre in the blood channels, while in all the proper transudation of the nutrient portions of the blood stream is seriously interfered with. These circulatory disturbances are often increased by the formation in the inner arterial sheaths of localized, circular, or nodular thickenings composed of fibrous knots or calcareous plaques embedded in dense fibrous masses, or deposits of fatty cholesterin matter covered by a thin fibrous-calcareous layer that during life protrudes into the lumen of the artery, cutting off one-third or one-half of its blood-carrying capacity. The favorite seat of these nodules is in the internal carotids just as they pass into the skull through the foramina. In the small arteries and arterioles changes are met with which, although differing somewhat in character, produce the same effect—namely, the shutting off of a sufficient supply of nutrient fluid from the brain tissues. Moreover, there occurs a retardation of the outward lymph flow both in the cerebral substance and in the pia mater, caused in part by the accumulation of débris of all kinds in the extravascular lymph spaces, and in part by thickening of the trabeculæ of the pia with accumulation of leucocytes, hæmatoidin crystals, and débris in the lymphatic channels. As a consequence the brain as a whole becomes ill-nourished; there is a degeneration of the white fibres both in the cortex and in the gray layers, with accumulation of a metaplastic material within the cells of the cortex and basal ganglia which may reach a degree sufficient to bring about destruction of the function and vitality of the entire neuron.

The psychoses of old age are, therefore, with few exceptions, essentially of an organic-degenerative nature, and possess especial brand marks, which distinguish them from the forms that occur in youth.

In all, the most striking feature is the loss of memory for recent events, while incidents in earlier life, temporarily at least, are retained. At the same time there can be noted an emotional childish tendency, accompanied by disturbances of the sensory, trophic, and vaso-motor nerves, followed in due course by apoplectiform and epileptiform attacks, which further increase the mental weakness, even though no actual paralysis is left behind. These insults are more frequently caused by the closure of an artery of medium or small calibre than by the rupture of its coats with consequent extravasation of blood and tissue necrosis.

Excluding senile dementia, which has been described as the "physiological death of the brain cell," and from which no man can escape should he live sufficiently long, we have, relatively as well as actually, fewer true psychoses among the aged than in middle life. Among 5,542 insane patients of all classes less than 14 per cent. (772) had become insane in the twenty years between sixty and eighty. The women outnumber the men to some extent, 416 females to 356 males.

The melancholias are far more frequent than the manias, and are characterized by an anxious, distressed, agitated, errabund state of mind. As hallucinations and delusions have not the same relative frequency as at an earlier age, the agitation may be regarded as an exposition of the malnutrition of the brain centres, and the tendency is ever toward a terminal dementia. Suicide is extremely common.

The manias are characterized by their blind violence, approaching in intensity that of the paralytic dement; the erotic excitement is often intense; the delusions assume an expansive form, the imagery is senseless, and the periods of remission are infrequent. Many of the sufferers from agitated melancholia or senile mania absolutely refuse food, rendering treatment more difficult, as artificial feeding may become dangerous to life itself.

Confusional insanities are now and then seen in the aged. At times these are referable to the accumulation within the system of toxic products that the senile renal apparatus is unable to carry away, to intestinal autotoxis, occasionally to the absorption of putrescent substances from a chronic cystitis, or an extension of a bladder inflammation to the pelvis of the kidney.

In aged persons who have retained a moderately good vascular condition one may encounter benign forms of insanity, which may result in a complete recovery. A careful examination of the condition of the peripheral blood-vessels may give the necessary diagnostic clinch, although, unfortunately, the cerebral arteries are often more diseased than those accessible to the finger.

Occupation.—Certain callings appear to be more frequently followed by insanity than others. Poets and artists are especially prone to the psychoses, not so much by reason of their occupation as from the possession of genius, which generally means inherited nervous ability, and from the fact that the nature of their work allows of much time for introspection. Among the working classes, certain employments from their debilitating nature are more prone to occasion insanity than others. Among these may be mentioned the employees of railroads, especially engineers who live a life of constant nervous tension, workers in lead, in mercury, in caoutchouc, or aniline products, iron-workers, and others who are almost continuously exposed to the effects of artificial heat.

The same holds good, although to a greater degree, for brokers, bankers, domestic servants, governesses, students, and day-laborers. Pro rata the lower the social class the more frequent are the psychoses.

II. Accessory Causes of Insanity.

These may be roughly divided into psychical and physical. It is often impossible to separate accessory factors from the underlying inherited taints, and for the most part careful inquiry will elicit a history of constitutional weakness serving as a background to the immediate cause.

1. Psychical.—*Anxiety.*—In a large proportion of cases of melancholia the immediate etiological factor is ascribed to the death of a near relative (mother, father, son, or daughter). Many are also directly caused by domestic worries, inability to meet liabilities, to provide properly for the family, and the dread of poverty. In the same category come business cares, loss of property, unsuccessful speculations, and similar reverses. It is hardly possible that these agents, in the total absence of constitutional predisposition, would be sufficient to interfere materially with the smooth running of the mental gearing, and though in rare instances such may be the case, for the majority an additional underlying cause must also be sought.

Exceptions of greater frequency may be noted in the instances of alienation closely following some business or domestic calamity occurring in old people, who though

they may not have derived neuropathic tendencies from their ancestors are themselves standing on the verge of a declivity, owing to advancing senile degeneration of the tissues.

Fear.—Numerous instances are recorded in which the witnessing of the commission of a murder, an attempt at assassination, the shock of coming into contact unexpectedly with burglars, an attempted rape, and other experiences calculated to produce a vivid mental impression, have been followed almost immediately by an insanity, the person within a few hours becoming stuporous or violently excited.

Examples of this kind are met with principally in individuals of weak mental organization, incapable of prolonged psychical effort and the disturbance for the most part must be attributed to the constitutional predisposition.

In the same class must be included a certain number of the psychoses of *child-birth.* The sudden lighting up of an acute insanity, occurring within a few hours of the parturition, can only be brought about by nervous instability. Not a few of the sudden manias coming on during the puerperium are merely instances of periodic insanity, the mental and physical strain incident to labor upsetting the hair-fine equilibrium and producing, what may be termed, a precocious return of the mental disturbance. Women who are always insane at the hour of parturition, and return shortly afterward to a more normal state, always belong to the degenerate class.

2. Physical.—*Poverty.*—Anything that depletes the bodily strength, if it is far-reaching enough, may become a factor in the production of an alienation. With indigence is associated bad and insufficient food, close crowding in foul air, and lack of hygiene in the widest meaning of the word. Hence it happens that the rank and file of the insane come from the poorest classes, and the crowding from country districts into towns, in recent years, has been very instrumental in increasing their numbers. Poverty also brings with it a host of attendant evils of which not the least is the tendency to make up for the lack of food by taking alcoholic stimulants which are cheaper and more satisfying for the moment. Actual starvation induces a delirium of the hallucinatory-confusional type, and may be a direct cause of alienation, which, however, is usually temporary if the case be treated early enough to save the victim's life.

Over-Exertion.—The over-exertion of the college gymnast, of the soldier during campaigns, or the strain incident to particularly arduous occupations, in which heavy weights are carried, as in the case of stevedores, favors the occurrence of changes in the vascular apparatus, that may lead, when youth has passed and early middle age is reached, to early senescence, and to organic-degenerative alterations in the central nervous system which eventually produce an insanity.

3. Constitutional Diseases.—*Anæmia.*—A dyscrasia, finding one expression in an anæmia, is present in all cases of the severer forms of melancholia, as well as in neurasthenic and other types of insanity. This habit of body is so common as to make one question whether the impoverishment of the blood is not the direct underlying cause. In the sense that it heightens any inherent tendency to irritability of the central organ of the mind it is undoubtedly an excitant, but deeper lies the instability of the protoplasm itself. Even when there is no actual psychosis, anæmic individuals often show a certain degree of mental incapacity with thought inhibition and irritability, and any strain, physical or mental, superadded to the dyscrasia, may cause the balance beam to oscillate violently.

Syphilis.—Next to alcoholism this is the most frequent direct cause of insanity. In addition it may also have an influence indirectly by lowering the resistance of the organism and producing a secondary mental indisposition. As a direct agent it acts by inducing widespread changes in the intima (less severe in the fenestrata and muscularis) of the arteries, the cellular proliferation being often so extensive as partly or fully to obliterate the lumina of the vessels. Under such circumstances there may be necrosis of the tissue areas supplied by the most damaged vessels, not confined to the brain but equally apparent in the extremities.

Intense vascular changes are not confined to the early stage of lues; on the other hand, they are more common with the secondary and tertiary manifestations of the disease. In a vast majority of paretics, particularly in those who have a clear history of specific infection, there is found, on examination, a soft thickening of the walls of the vessels, a change for the most part due to an obliterating endarteritis of a peculiar type.

Luetic neoplastic endarteritis has been encountered as early as four weeks after the occurrence of the initial lesion (G. de la Tourette, Alelakoff, Berkley), or as late as twenty years after the infection.

Besides the specific arterial degenerations, syphilomata and gummata may also occur within the cranial cavity, disturbing the return venous and lymphatic circulations and producing congestions and œdemas.

When the syphilitic process is acute the form of mental disturbance assumes a furibund, excited character followed by stupor; with the more chronic changes the excitement, though less intense, is usually more prolonged, and may be followed by pareses, paralyses, or epilepsy, the final stage being a terminal dementia. The greatly increased frequency of the cerebral complications of syphilis in recent years, together with their protean character, is exceedingly striking, and is a comment upon the civilization of the present era.

In strong contrast with the records in this country of a multitude of mental troubles following syphilitic infection is the report of Holzinger of the Russian Red Cross Commission to Abyssinia during the Italian war. In a country where according to his statement eighty per cent. of the inhabitants are syphilitic, only twelve true psychoses occurred among thirteen thousand patients seen in a general dispensary, and none of these appeared to be directly due to the taint. In the same land tabes dorsalis (six in thirteen thousand), and dementia paralytica (none) are extremely infrequent. Either the luetic virus of the East is different from that of the West, or the constitutional proclivities to mental maladies vary very much.

Tuberculosis.—This is an infrequent cause of insanity, and when it is present it usually succeeds instead of preceding the alienation.

Heart Diseases.—Cardiac lesions do not appear to be more frequent among the insane than among the sane. Those that lead to embolism are responsible for a larger proportion of the alienated than simple insufficiencies.

Kidney Diseases.—Mental disturbances are relatively frequent in the chronic forms of nephritis, especially with the contracting kidney, and with diabetes mellitus. In chronic uræmia there is often alteration of the character, delusions generally of an expansive nature, or stupor, even when the urine shows neither the presence of any considerable number of casts nor a trace of albumin.

The non-elimination of the effete products of bodily waste is responsible for the evolution of the insanity in these instances, just as the effects of other chemical or toxalbumic poisons manifest themselves as a psychosis, the mental disturbance assuming the form of an hallucinatory-confusional insanity.

Diseases of Women.—It is noticeable that organic diseases of the uterus and its appendages (carcinoma, fibroma, etc.) are seldom accompanied by profound nervous storms. On the other hand, the leucorrhœas, amenorrhœas, profuse menses, vaginismus, chronic uterine catarrh, and a host of other comparatively benign affections are now and then followed by mental disturbances.

It is probable that the latter act upon the system in two ways: first and foremost they deplete it and induce blood depravities; and secondly, they lead to the fear that some incurable disease is present. In highly neurotic individuals an ever-present dread is likely to be a factor of considerable moment. Although it may be said, in general, that the influence of the affections of the generative ap-

paratus as a cause of insanity in women has been exaggerated, as an accessory factor it is often worthy of consideration. Diseases of the generative organs in men seldom lead to alienation.

III. Direct Causes of Insanity.

It is never possible absolutely to separate inherited predisposition from the direct effects of deleterious drugs, febrile disturbances, and traumatism, so far as regards the degradation of the cerebral substance. Certain suggestions are afforded by the clinical phenomena resulting from such agents that render it very apparent that an invalid brain is much more readily overthrown by them than a sound one. Mark, for instance, the difference of the effect exerted by a febrile disturbance in a child the offspring of neurotic parents, and in one who comes of sound ancestry. With only a very moderate degree of fever the first child may exhibit a wild delirium with the evolution of vivid sense phantasies, while the other may not be appreciably disturbed. Again, in cerebral traumatism, a slight commotion may set up a train of psychical symptoms in the neurotic, while in the other the mental capacity remains unimpaired.

1. Chemical Poisons.—*Alcohol.*—As has already been said, although syphilis may be a direct agent in the production of an insanity, its poison acts not upon the brain cells immediately, but upon the blood-vascular tissues, the nerve and neuroglia elements never being primarily involved. Alcohol, on the other hand, exerts its noxious influence alike upon mesoblastic and epiblastic elements, with the result that both suffer in equal or diverse degrees. An over-dose of alcoholic liquor acts by causing, first, congestion of the brain, and later paralysis of the walls of the vessels, inducing stasis and œdema with profound unconsciousness. If the same effect is produced time after time, the vaso-motor paralysis leads to the permanent widening of the blood-vessels, especially of the arterioles and capillaries, with lowering of the vascular tonus. As a sequence we have lymph stasis with exudation of the white elements into the sheaths, and clouding with thickening of the pia-arachnoid. At length the alteration of the arteries becomes chronic, the sheaths undergo fatty-atheromatous changes, and there is established an arteriosclerosis with some narrowing of the lumen from thickening of the intima, which is in part compensatory. At a later stage fatty degeneration of the heart muscle may ensue with increasing defects in the circulation.

With the alcoholic arteriosclerosis come changes in organs of the body other than the brain, cirrhosis of the kidney and liver being the most frequent.

The effects of ardent spirits upon the human brain varies with each person. Upon certain individuals large quantities seem to have no immediate bad influence, beyond the slight immediate flushing and depression of the circulation; while in the case of others a few glasses of wine or liquor will entirely overthrow the mental equipoise and render the drinker temporarily insane. In a very few, an equally small dose, perhaps the first and only one of their lives, will permanently disturb mentalization, so that the unfortunates retrograde to the plane of dements.

From a psychical standpoint the evil effects of alcohol are usually shown in two ways. If a large quantity be taken at one time the result may be an immediate breaking down of the mental powers, so that there is produced an effect similar to that of various other irritant poisons —an acute hallucinatory excitement with thought inhibition. In the case of the alcoholic the condition is known as delirium tremens.

On the other hand, if the doses of liquor be small in amount but frequently repeated the same result is finally attained, the duration of resistance depending upon the individual, the frequency of the drinking, and to some extent upon the quality of the liquor partaken of. Since physiological experiments have shown that it takes about two days for the organism completely to eliminate alcohol, it is clear that if dose follows dose in rapid succession and an insufficient time is allowed for the expulsion of what is present in the body, an accumulation of the poison within the tissues must take place, which in the ordinary course of events will ultimately produce a nervous explosion—the so-called trembling delirium.

If, on the other hand, the ingestion of the drug is slower, but is constantly continued and fatty degenerative changes are set up in the tissues, particularly in the arteries and nerve cells, the result is an insanity of a more chronic type—persecutory psychoses, manias and melancholias of especial character, a pseudo-dementia paralytica, as well as amnesic and epileptic states. Characteristic of all forms of alcoholism is the peculiar mental clouding known as amnesia, and an unreasoning irritability and suspiciousness.

If the individual who abuses alcohol was the only sufferer from its deleterious effects, the crime of its misuse would not be so great, but unfortunately this is not the case. Even unto the third and fourth generation the effects of the poison may be traced in constitutional neuroses, psychoses, early mental break-downs, and eventually imbecility and idiocy. Drunkenness on the part of the parents is represented by feeble-mindedness and epilepsy in the offspring, while statistics show that intoxication in both parents at the moment of copulation induces a larger proportion of the lower grades of idiocy than any other single factor.

Intemperance is directly the cause of about ten per cent. of all cases of insanity encountered in asylums. Indirectly the figures assume colossal proportions when we include the psychoses and psychoneuroses of the descendants of alcoholic parents that are attributable to the ancestral vice. Women afford only about one-third as many examples of alcoholic insanity as men, but in the lower classes this disproportion is much decreased.

Besides the alcohols there are a large number of poisons and chemical substances that produce a direct alienation. usually of the hallucinatory type. Among these may be mentioned cocaine, atropine, morphine, salicylic acid, iodoform, antipyrin, nicotine, chloroform, ether, chloral, illuminating gas, carbon disulphide, and numerous others.

The metals, lead and quicksilver, act upon the organism somewhat differently. They are essentially of the nature of chronic poisons, and while they may occasion an hallucinatory delirium with much motor agitation of a transitory type, the peculiar nature of their action is to evoke a permanent insanity with hallucinations and delusions approaching the character of a dementia paralytica and ending in mental annihilation.

2. Auto-intoxications.—*Intestinal.*—A profound obstipation, with absorption into the circulation of certain products resulting from the splitting up of albuminous substances within the intestinal canal, as shown by the presence of indican and skatol, or of other less readily recognized substances in excessive amounts in the urine, may be the cause of an acute insanity, and as an etiological factor is too frequently overlooked.

Cases of this nature are by no means uncommon, and should the inducing agent be recognized and the proper remedies applied to correct the faulty digestion, they are usually readily curable. According to the degree of mental instability we may find conditions varying from simple obtundity to actual stupor; or a true psychosis, commonly of the melancholic type, may develop. On the other hand, the case may assume an alternating character, melancholia changing into mania, to be succeeded by stupor. Uræmic and diabetogenous insanities have been already mentioned in another paragraph.

Among the autochthonic insanities the occurrence of an alienation following the disturbance of the secretion of the thyroid gland in the adult should be remembered. Examples are now and then met after disease of the gland, after child-birth, and occasionally without any ascertainable reason, in which the skin becomes doughy and foul, the face assumes a half-moon appearance, and soon an insanity manifests itself. The psychical torpor

steadily increases, and eventually there may be melancholic depression, or excitement with hallucinatory delirium, followed by stupor.

The majority of these conditions are curable if proper measures be instituted. In some examples of Graves' disease there is also met a form of maniacal or melancholic insanity which does not yield so readily to the thyroid treatment.

3. Acute Febrile Disturbances.—The occurrence of an insanity during or after an acute febrile disease is by no means rare, but inasmuch as these cases are for the most part treated in private or general hospitals statistics as to the actual frequency are lacking. Wille gives 0.81 per cent. of typhoid fever cases as having post-febrile alienation, a not inconsiderable number in the aggregate when the frequency of this disease is considered.

Febrile psychoses may occur in either predisposed or non-neurotic persons, in the latter case intensity of the disease process overwhelming the natural tissue resistance.

The common mental disturbance that occurs during the acme of the fever is termed *delirium*. It is characterized by illusions, hallucinations, temporary facility of thought with confusion and interference with the ordinary association of ideas. Such departures from normal mentalization are produced by three agents: the rise of bodily temperature, the increase of the respiratory and circulatory activities, and lastly, but not least in importance, the impression made upon the vitality of the tissues by the toxin of a micro-organism circulating in the blood and bathing the cells in a vitiated serum.

True psychoses do not accompany but follow the febrile disturbance: the acme of the fever is past, the excessive action of the heart has subsided and its contractions have fallen below the normal in force, while the toxin of the specific bacterium has been to a great extent overcome by the natural tissue resistance, though there may still remain within the organism sufficient to vitiate the nutrient plasma.

The condition is now one of profound nutritional perversion with blood depravity, and irregularity or actual disturbance of the circulation from cardiac weakness. At the same time there may also be venous congestions and œdemas of the cerebrum, arising in some instances from actual damage to the arterial sheaths from the immediate effects and deleterious after-results of toxalbumins engendered in the course of the acute disease. The mental disturbance induced by these several factors is therefore in the nature of an exhausting or collapse delirium. It is apt to be stormy in its onset, confusion being the predominating characteristic, accompanied by visual and auditory hallucinations, rapidity in the change of thought from one subject to another, and increasing mental obtundity. In addition there is generally active motor excitement and entire sleeplessness. The bodily temperature is now subnormal, the heart's action is feeble, and the reflexes are slightly elevated. The condition may last only a few days or may continue for several weeks.

Typhoid fever, influenza, pneumonia, scarlet fever, measles, erysipelas of the head, polyneuritis and variola, in the order named, are the most frequent of the exanthemata to be followed by psychoses. Before the introduction of quinine malarial fevers added a considerable quota to the ranks of the insane. Probably the blood-letting then in vogue often aggravated the nervous phenomena. Even to-day in countries where the severer forms are encountered, about two per cent. (Pasmanik in Bulgaria) of those affected have some mental complication, usually stupor. The debilitating effects of a marked paludal intoxication would often account for these disturbances of the mental equipoise, though plugging of the capillaries with aggregations of the parasites may play a not unimportant part. A number of the psychoses accompanying *parturition* must be classed among the febrile insanities, as they are the result of infection by cocci that have entered through the uterine passages, notably the placental site. The organism most constantly found is the Streptococcus pyogenes.

4. Corporeal Insults.—Meningitis of a severe character is not uncommonly followed by a form of insanity approaching mania. The inflammation of the brain coverings, the disturbance of the circulation in the cerebrum, the obstruction of the pathways for the returning lymph along the vessel sheaths passing finally into the pia mater, together with the increase in the intracranial pressure are sufficient to account for the perversion.

In tumor or abscess of the brain, in primary internal hydrocephalus of the adult, in disseminated sclerosis, after apoplexies and embolisms as well as other local abnormal conditions, insanities are now and then encountered. They usually assume the form of a progressive dementia, the patients only occasionally exhibiting depression or exaltation, though rarely after a hemorrhage or embolism of one of the larger arteries of the brain, conditions of frenzy are seen.

Trauma and Insolation.—All degrees of injury to the skull and brain tissues may be followed by an insanity, sometimes coming on immediately after the reception of the lesion, while at other times it may be postponed and remain latent for months. A trivial local traumatism, especially in the case of persons suffering from some constitutional disease, as syphilis, may start up an inflammation of the tables of the skull and the meninges beneath that eventually may implicate the brain, either by direct extension of the process or by pressure upon it. At other times, again, the neoplasm following the injury may interfere with some of the exits of the venous blood and the lymph fluids from the brain cavity and evoke an alienation. Active motor excitement is less common than a dull apathy with loss of memory and weakening of the faculties. An apparently trivial injury may also be the match that lights up the flame of a periodic insanity, circular or maniacal in type.

The form of alienation that follows insolation is also ordinarily a dementia of passive type, though now and then a series of mixed motor-psychical phenomena, strongly suggestive of the demented form of paresis, is seen. The condition results from the degenerative effects of the thermic fever upon the cortical gray matter, inducing changes in the vascular lymph apparatus and degradation of the cellular elements.

Operations.—Instances of insanity following surgical operations are somewhat rare. In this connection the mechanical shock to the nervous system, especially in the case of an unstable subject, and the effects of the ether or chloroform are elements to be considered. Operations that involve an extensive loss of blood are, perhaps, more commonly succeeded by an acute alienation than minor surgical procedures.

Operations upon the eye and castration are said to be especially dangerous. Simple *anæsthesia* from chloroform or ether has occasionally been followed by a psychosis of short duration. The mental impression induced by the dread of the procedure and the fear that death would occur during the narcosis, together with the systemic effect of the drug, all play their part in the overwhelming of the faculties. The precocious advent of a periodic insanity must also be borne in mind.

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IV. INSANITY: GENERAL PATHOLOGY.—To bring the data observed in the cases of insanity in line with the data of pathology generally is a very difficult task on account of the heterogeneous character of the material. It is safe to say that for a general pathology there must be sound material of special pathology. The literature of special psychiatry is, however, unfortunately, more conspicuous by quantity than by broad scientific points of view, and only here and there we can discern successful efforts to bring the observations on the level of standards which hold for pathology generally: trains of established evolution and causal connections. The following sketch is an attempt to show the principles with which we proceed to-day, and for examples we must refer to the articles on special pathology.

The Data of Psychiatry.—The phenomena which we get for the formation of a scientific picture of a case of mental disease are, *First*, the general data concerning the family type and the occurrence of special diseases in other members of the family. *Second*, the data concerning the condition in which the patient entered the causal constellation which we designate as the disease. *Third*, the string of phenomenology or symptomatology of the entire disease; (*a*) the deviations of the course of reactions in which the mental phenomena are essential features, the mental symptoms proper (including as much as we actually know of the objective or physical signs of "mental" reactions); (*b*) the disorders of the organic mechanisms (circulation, digestion, respiration, secretion, reproductive organs, and nervous system); (*c*) the findings in autopsies, the anatomical findings of the deviation from the normal processes of life, naturally obtainable in only a portion of the cases, because few die of the "mental" disease. This group of data is often treated separately for practical reasons and on account of the character of the method of investigation; but so far it has been but little productive in the general frame of a pathology of insanity.

To reduce these heterogeneous data to some sort of useful and practical order and especially into strings of causal connection is the task of a general and special pathology of insanity.

The distribution of the work in this Handbook has decentralized the analysis of the various groups mentioned above. It will be necessary, however, to encroach upon the fields of other contributors at least to the extent of showing some of the principles which guide us in the utilization of the various facts for reasoning in pathology.

There are two ways of entering upon the study of mental aberrations. First, the consideration of *disorders* which are *produced* experimentally and under definitely known conditions. Second, the study of the *phenomena* of insanity as they present themselves *in a large practical experience*. These two proceedings must co-operate and tend toward the ideal that we should be able to understand all the happenings in mental pathology with principles of thought which come up to the accuracy of those of experiment. The extent to which this can be obtained is identical with the extent of accurate knowledge of the pathology of insanity.

Considering the large number of varying types of deviation from the normal and the small number of experimental products in these lines, we find ourselves forced to lay the emphasis on the purely empirical material of the physician, and we shall investigate how we can hope to bring some order into the immense material. It is rather striking that most of the serious study has been paid to the things which are most difficult to establish and interpret properly, viz., to the problems of heredity and to the problems of pathological anatomy. Either of these lines is not usually accessible to actual observation; the one represents hearsay facts and the other seldom facts which can be directly related with the actual psychosis; and it must be our attempt to work for a more satisfactory position of the variations of life processes in the general scheme for studies. That is to say, we must learn to use for diagnosis, prognosis, and therapeutic possibilities that which we actually meet in our practical problems, the symptom complexes and their causal connections, and the evolution of the symptoms.

The Data of Heredity.—In order to make up for the meagre data concerning the foundation of insanity in the individual, the alienist has attached great value to the finding that in a great number of cases the patient is not the only member of the family that shows abnormalities. The family history of any moderately large group of cases of insanity shows a relatively frequent occurrence of mental disorders, nervous disorders or various "diatheses," and the conclusion is drawn from it that where there is a "history of gout, rheumatism, diabetes, gravel, phthisis, migraine, epilepsy, asthma," or of peculiarity of character, criminal record, or nervous or mental disorders in one or more persons of the family, a "morbid taint is fully established." Under the influence of the general views of evolution and dissolution the concept of the *morbid taint* has moreover been closely associated with the concept of *degeneration*.

The data of heredity of mental disease have been brought into prominence chiefly by Morel and under the influence of Magnan and Lombroso and their associates.

From the great amount of literature we select the following types of contributions. On a very favorable material in a Canton of Switzerland in which the movements of the population are not excessive, Jenny Koller* has studied the histories of 2,273 patients admitted between 1881 and 1892. Heredity was noted in 78.2 per cent. In 64.3 per cent. of these cases, or 50 per cent. of the whole, there was direct heredity—a disorder in the father or mother, or in both; in the rest, heredity was collateral, or atavistic. The heredity is somewhat greater in the women than in the men, 81.7 per cent. against 74.9 per cent. The material of comparison consists in the accurate family history of 370 mentally healthy individuals of the same layers of the population, and 370 consecutive admissions of the years 1885 and 1886 were chosen for immediate comparison; and the facts were classified in the following table:

	A—Normal series.		B—Insane series.	
1. Mental diseases.....	57	26.1 per cent.	39.8 per cent.	113
2. Nervous disease	38	17.4 "	10.2 "	29
3. Alcoholism	55	25.2 "	22.2 "	63
4. Apoplexy	36	16.5 "	5.6 "	16
5. Senile dementia	10	4.6 "	2.8 "	8
6. Peculiar character ..	16	7.3 "	18.0 "	51
7. Suicide	6	2.8 "	1.4 "	4
	218			284

The next table gives the relative percentage of direct, indirect (atavistic), and collateral heredity.

A comparison shows how very important the direct heredity of mental diseases and peculiar character of the parents is among the insane, whereas nervous disorders and apoplexy and even suicide happen to be found in larger numbers in the families of the normal than in the families of the insane.

Ball and Régis ("Les familles des aliénés," *l'Encéphale*, 1883) described a definite "cachet" of heredity in the descendency of various mental disorders. In normal families the causes of death are greatly varied and distributed in almost equal proportions among the various groups of

* Archiv f. Psychiatrie, 27. Bd., S. 286.

	Direct.		Indirect.		Collateral.	
	Normal. Per cent.	Insane. Per cent.	Normal. Per cent.	Insane. Per cent.	Normal. Per cent.	Insane. Per cent.
1. Mental disease	10.1	25.4	11.9	7.7	4.1	6.7
2. Nervous disease	11.0	7.4	4.6	1.8	1.8	1.0
3. Alcoholism	14.2	19.0	10.5	2.2	.5	1.0
4. Apoplexy	7.8	4.3	8.2	1.2	.5	
5. Senile dementia	.5	2.1	3.6	.7	.5	
6. Peculiar character	3.2	15.8	3.2	1.2	.9	.7
7. Suicide	.9	.7	1.9	1.1		
Sum of factors of heredity.	47.7	74.7	44.0	15.9	8.3	9.5

disease; there is no special tendency to repeated affections of the same apparatus. Ball and Régis showed that general paralysis is followed chiefly by brain affections; while mental disease and neuroses, alcoholism and consumption are not more frequent than in the normal. Non-organic insanity is followed by a diathesis of insanity, while brain disease, neuroses, alcoholism, and consumption are not abnormally frequent; epilepsy is followed chiefly by brain affections in childhood, while phthisis and alcoholism are prominent in the ascendency; epilepsy itself is rarely transmitted as such; hysterism is followed most frequently by nervousness; alcoholism by a disposition to phthisis and brain diseases in childhood. Morel points to a frequently quoted progressive type of familial degeneration in alcoholism which leads to decline, to idiocy, within four generations. Experience certainly favors the statement that the existence of cases of mental disorder opens greater statistical chances of developing mental disorders in other members, and where this fact is present in a family the disorders are apt to appear at an earlier age and to show a greater tendency to relapse. On the other hand, hereditary attacks are often slighter and more curable and the danger for life is less. In a large number of individuals with insanity in the ascendency there are no psychopathic traits at all; moreover, in many patients with essentially degenerative phenomena the hereditary data are negative. The assertion that "the subject of ordinary insanity is not a normal individual, that there exists in his constitution a latent disposition which any accidental determining cause may at any moment transform into evident symptomatic manifestation" has its corrective in this last remark and in the experience that there are "thousands of predisposed persons who escape the graver risks of their faulty inheritance and pass through life untarnished by insanity."* In order to make the occurrence of mental disorders intelligible in some people, we pass over a large percentage of humanity a verdict as gloomy as the dogma of infant damnation, unless we recognize the limitations of the statistical method and do not overdraw its positive and negative value. True to the fact, pathology should avoid this unnecessary evil prognostication, except where it is actually justified by the events. For the purposes of real individual pathology, we are obviously forced to search for more important data which would explain how it is that a certain proportion of members of families "with a morbid taint" tend to represent an abnormal variety. We are encouraged in this direction by almost all the data above mentioned, if at least we know how to read between the lines, especially such facts as: that educational influences under mere peculiarities of the parents or criminal surroundings are far more serious than the record of a decided attack of insanity of one of the parents, and that forms of insanity classified as particularly hereditary not infrequently occur without any evidence of "heredity" at all.

For principles of pathology we cannot admit statements about heredity as digested material except:

(1) Where they apply to large numbers, and mean to be of general bearing;

* Macpherson: "Mental Disorders," p. 22.

(2) Where we have sufficient certainty that the feature attributed to heredity cannot be explained more directly on grounds of influences during growth, education, and other determinants of the individual life; and

(3) Where the *corpus delicti*, the inherited feature, has a sufficient relation to the disturbance of health.

These clauses are meant to apply to the so-called "stigmata." They will exclude completely a considerable number and place another large portion on the list of true accidents of *development* for which the pathology of growth is still to be worked out before they should be used for more than signs of mishaps of growth, the bearing of which should be stated in every instance and case. I should repeat concerning them a remark made in a review of the "Signs of Degeneration and of Methods of Registration" in the *American Journal of Insanity*, January, 1896, p. 345: "Probably for a long time to come the study of mental capacity and potentiality will be best carried out by studying the psychical manifestations rather than the physical forms of the person," inasmuch as the majority of the physical signs of degeneration are utterly uncorrelated facts, and of value only as remote collateral evidence of difficulties of development.

These critical remarks do not attack the facts of heredity but their looseness and hasty interpretations. There are indeed some types of mental disorders which we look upon as constitutional in the sense of familial, and some types of disease which might be called at least equivalents of one tendency (dissimilar heredity). But it is of no small interest to see that in these heredity is not always the only possible or even probable explanation, and that we probably go too far in appealing to the dogma without enough analysis.

A final reference may be made to the very noteworthy study of Dr. Vorster, of Stephansfeld. Eleonor Fitschen had found that positive hereditary data were not more frequent in periodic (manic-depressive) insanity than in mental diseases generally, but that there was a greater number of real mental disorders mentioned. Vorster has shown that in families with manic-depressive insanity he found seven with exclusively manic-depressive insanity in the ascendency, and in none of them any cases of dementia præcox; in eight families with several cases of dementia præcox there was no case of manic-depressive insanity. This article* is worth quoting for the purpose of possibly dissipating a number of traditional illusions of the frequency of heredity and of the relative value of factors and as an instance of what precautions are needed for valuable studies in this field.

The Data of Etiology.—Looking over the determinants of make-up and of deviations of life implying mental disorders, we again meet with the problem of heredity with most writers. At the present stage of biological knowledge, especially in view of the facts collected by Weissmann, we see in the liberal use of principles of generic life little more than the term for the unknown quantities in the concept of *constitution of the individual.* Constitution is the sum-total of the make-up of an individual. Every good history of a case of mental disorder should give us accurate information concerning the make-up of the person before the complex constituting the disease was complete. The types of make-up are approximately grouped as types of constitution, as far as possible without reference to the final event which is supposed to enter only under definite additional influences.

The concept of constitution has come into discredit because pathology has been more fortunate in detail work than in this general problem. Kraus and Martius have finally put it on truly pathological foundations, *i.e.*, on principles which can be understood from what is accessible to study, and does not need the designation from a merely possible result (as, for instance, in the term apoplectic constitution; we should not speak of an apoplectic constitution, but of the presence or absence of arteriosclerosis). Kraus has pointed to the tests of fatigability

* "Ueber die Vererbung endogener Psychosen in Beziehung zur Classification." Monatsschrift für Psychiatrie und Neurologie, April and May, 1901, vol. ix.

as a measure of the constitution of the heart; and Martius to similar types of function in the stomach, and more directly in our field we find the study of individual types of neuromuscular reactions taken up by the schools of Kraepelin, Sommer, etc. They are only fragments, though but a no longer mystical attempt to bring a useful order into the descriptions of the make-up which the clinician already distinguishes as types of instability, etc. In ordinary language, we do well to look to the nature and extent of the development, the habits and the efficiency, as the chief features of the constitution of an organ or an entire person. The features of comparison must be chosen somewhat arbitrarily, but with preference among items which can be brought in line with other biological facts, constituting diseases. Thus, the pathologist will arrange people from points of view different from those of the moralist or the artist or ordinary statistician.

Psychiatry has done little in the differentiation of types so far. It limits itself to the general classification as to whether a person is neurotic or not. We need further subdivisions. Kraepelin supposes that one developing paranoia must show from the start traits different from those of the hysterical or the manic-depressive. In a general way, our hope for clews lies in the direction of studies like Kraepelin's (mainly from the point of view of fundamental characteristics of neuromuscular and mental reactions studied under the influence of fatigue, practice, toxic interference, etc.); further, of studies concerning the influence of variations of habits and functions of other organs on the nervous system, the ease of reaction to toxic and autotoxic febrile influences, and the existence of types of abnormal metabolism, such as may perhaps lie behind the group of facts covered by the claims of the uric-acid theory. And for practical orientation we use characteristics like those of sociability or seclusiveness, efficient and systematic or desultory nature, determination or oscillation, social or anti-social instincts, normal or abnormal sexual life, the existence of definite psychic peculiarities and defects, etc. For practical purposes and for possible avenues of research all these features offer problems nearer those of fundamental individual pathology than the theories of heredity can offer, because they are present in the available subject of our study, the patient.

The other factors which are necessary to make complete the conditions for the development of mental disorders are in about the order of their frequency: direct and indirect toxic effects of alcohol and other poisons; direct or indirect consequences of infectious conditions; direct or indirect damage of the nervous system by senility, organic lesions, etc.; and effects of exhaustion, or the occurrence of excessively dominant preoccupations. However vague some of these general designations may appear, their usefulness in modern mental pathology makes them a worthier subject of investigation than are many high-sounding speculations. The article on etiology will enter more fully on this topic.

THE PATHOLOGICAL VALUE OF THE EVOLUTION OF SYMPTOM COMPLEXES.—The data of this part of psychopathology are to be found in the fields of clinical investigation and post-mortem manifestations.

In reality, most of the components which determine mental diseases belong already in the field of symptomatology, *i.e.*, of manifestations of abnormal conditions. A further point for consideration, a very important one, is the form of termination which closes the working of the disease principle. From the sum total of the manifestations and their causal evolution we are accustomed to derive an abstract principle of the "disease type" or "disease process." To this is referred the whole string of events which we have reasons to designate as abnormal.

At first sight there seems to be a formidable chaos before us, especially when we find ourselves under the influence of a feeling of inadequacy produced by the older efforts of school-psychiatry in these lines. Their abstract half-philosophical classifications do not fit into the ways of thought of the physician. Hence the traditional sigh: There is no pathology of insanity as yet. In reality the conditions are not at all hopeless. The experimental neatness of bacteriological pathology makes us too fastidious and perhaps also too lazy to develop standards and methods of other lines of pathology, such as are needed for the pathology of the skin, or of the kidneys, or of the liver, or of digestion, where more than bacteriology and also more than histology is needed to reach the standards of experiments. What we know of the pathology of the various forms of Bright's disease, or of cirrhosis of the liver, or of diabetes, or even of the condition of development of some forms of pneumonia, is not a particle clearer than are the few facts which we possess for the appreciation of delirium tremens, or general paralysis, or even dementia præcox, although we can boast that our inventory of distinctive manifestations is rich in palpable and also microscopically magnified post-mortem findings. The anatomical findings are as much in need of a "pathological" explanation as are all the other manifestations. Just as in many diseases in which mental reactions are not involved, the establishment of causal chains of so to say experimental strength is not far advanced in psychiatry; but there are valuable beginnings and there is much material for a natural and useful classification of the deviations from the normal and a good start for a "mental" pathology.

This is, of course, excluded if all the work is limited to grouping the features according to the scholastic division into mental symptoms, and functional (dynamic or physiological) and physical or morphological manifestations without due consideration of their evolution. Attempts are usually made on the "physical" side, and those on the "mental" side are classified and arranged logically, but not sufficiently as part of the whole economy. As soon as we analyze mental facts we follow the path of least resistance and think more of logical justification than of the relation to the trend of the individual biological household. We get satisfied with the fact that a depression is not adequately founded; that voices are heard or things seen which are not there, that the patient is suicidal or dangerous, etc. In other words, we adapt ourselves to be satisfied with what the judge needs for the commitment. We see, however, no reason why we should not embody the reactions of the individual which happen to have the quality of mental reactions, in a general plan of the individual human household, with due recognition though that morphological facts and physiological facts and mental facts are recognized from different standpoints, overlap, and must be reduced to a common denominator before they can be material of a harmonious pathology of experimental accuracy. Even without an ideal simplification, we can establish sufficiently valuable strings of facts to refute the belittling comments of mere resignation.

The analysis of a large number of faithful records of cases of insanity furnishes certain natural groups of almost identical conditions. The similarity may lie in the etiological constellation, or in the temporary symptom complexes, or in the general course with reference to sequence of symptom complexes, or with reference to the outcome of the whole process and the events in the subsequent life of the patient. Where there is a coincidence of the main points in all the four directions we have every reason to surmise a definite law of development, especially if the type occurs often enough to free one of the impression of chance. Where three or only two of the directions coincide, we have at least reason to search for the value of the points of coincidence as compared to those of difference.

Our habit of seeing in the successful experiment the proof of an empirical claim leads us to give very strong prominence to the *etiological constellation.* The difficulty of establishing it is, however, not small. Not only do we often fail to get the necessary accurate information, but even where the conditions develop under our eyes we often fail to be able to foretell what the effect and the outcome will be, on account of the acknowledged personal differences which we are not able yet to estimate

with more than approximate accuracy. The most common illustration met with in practice is that of alcoholic insanity. From the mere pathological forms of intoxication to the delirium tremens, and the subacute alcoholic hallucinosis, and finally the chronic alcoholic paranoia and the alcoholic polyneuritic psychosis and pseudo-paralysis and alcoholic senile affections, and recurrent "alcoholic" mania, or "alcoholic" dementia præcox, we see the factor alcohol enter a number of sets of constellation with a rôle of variable importance, and we see clearly that the etiology cannot be exhausted by one factor. It is a complex function of one or more determining factors with definite types of make-up and temporary or lasting conditions (such as gastritis, or states such as are characteristic for epilepsy, periodic insanity, or dementia præcox or senility), the coexistence of which makes the condition more complicated but in principle at least none the less as clearly accountable for the consequences as if only one factor were needed for an experimental test.

The value of symptom complexes as such has probably been overrated at various times. Some of them have caught the attention as typical because they seemed plausible and were easily described and communicated, from the point of view of the normal, such as depression, etc. Others are refractory and scarcely described in most text-books. As such, the value of symptom complexes for the estimation of pathological processes cannot be tested too carefully. Even short experience shows that apparently identical symptom complexes occur under so variable conditions that conclusions drawn from a temporary picture as to etiology and outcome and the general nature of the conditions are apt to be guesswork. The most valuable determining feature is, as a rule, the *form of evolution* of the complex, the time and duration and circumstances of its development, and the character of possible transformations of the picture. The great wealth of forms does not exclude the justification of the hope that at any given moment we may learn to find features characteristic for definite special types of evolution, such as we see in a certain kind of disorder of the sensorium, in certain acute delusional episodes, or in monotonous and strained productions in hebephrenic and catatonic excitement different from the excitement of simple or recurrent mania, etc. Distinctions will strike us only if they are suggested by definite *demands* for distinctions built on the experience concerning types of definitely known etiology and evolution. In the evolution of the symptomatic phenomena the *form of the outcome* is probably next in importance to the etiology, inasmuch as it furnishes an index to the amount and nature of damage done. Classical instances are general paralysis and Kraepelin's manic-depressive insanity. Both these groups show moreover that the forms of the symptom complexes may appear fundamentally different and variable unless we consider their evolution, which shows them to be empirically referable to just one typical form of general course and outcome. General paralysis with its fairly established etiological constellation and its almost uniformly demonstrable dementia and neurological disorders and fatal termination offers a large variety of symptom complexes which we can grasp correctly only if we are familiar with specific traits that characterize the disease as a whole and especially the form of dementia and the combination with disturbances of the nervous apparatus proper, over which even remissions simulating recoveries cannot, as a rule, deceive a trained diagnostician. And manic-depressive insanity certainly shows us that a disorder strikingly characterized by its run in definite attacks with little tendency toward dementia offers many equivalent symptom complexes of greatly different appearance and nevertheless must be recognized as at least an empirical entity, with fairly distinct fundamental symptoms. No form shows better how much more fundamental symptoms mean for pathology—*i.e.*, an understanding of the bearing of a disorder—than this one contrasted with the mere superficial divisions into "mania" and "melancholia," the "attendants' diagnoses" of most statistics.

It is obvious that as psychiatry progresses, the recognition of large types or nosological entities leads to further detail investigations of the temporary symptom complexes and that the results of the latter may, in return, demand considerable readjustment in the concepts of large types. We certainly have sufficient reasons for the presumption that it is possible to recognize definite types of evolution of disease; that for the various types which show superficially similar symptom complexes, we may learn to find distinguishing features from which to draw distinctive conclusions for diagnosis, prognosis, and treatment. Only inasmuch as division into types and classes leads to actual advantages, they will have an interest from the point of view of pathology. Classifications for the simple purpose of reducing the chaos to a merely logical order without any help in the direction mentioned is to be looked upon with suspicion as possibly a soporific for actual purposeful investigation. For some time to come it will be desirable to make many groups, to avoid deceptive simplicity, to remain on the ground of carefully observed series of cases, and to take generalizations as purely hypothetical temporary helps, unless the conditions which hold for experiments can be said to be thoroughly observed.

Whatever general classes we adopt we must see that they form steps toward the finding of common denominators of the mental, functional, and morphological symptoms. We study them all from the point of view of types of reaction of the whole individual rather than that of purpose or that of purely mental symptoms. What impresses us as mental symptoms involves, as a rule, movements of expression, and changes of circulation and chemism, and apart from these changes co-ordinated with the mental symptoms as they appear to us, there may be special disturbances of the organic mechanisms of the body without direct correlation with the mental symptoms but of deep importance in the whole disease process. We put down the established facts in a loose chain connected only as far as our actual knowledge goes, and we frame our provisional disease picture with due reference to all the features: etiological constellation, evolution of the symptom complexes, course and outcome. Experience shows that this method furnishes general concepts of great use in formulating diagnoses which mean something for prognostic and therapeutic purposes, and that it puts workable problems for investigation into our hands.

THE METABOLISM IN PSYCHOSES.—Much has been made of the importance of metabolism and of auto-intoxications during the late nineteenth-century revision of humoral pathology. Unfortunately there exist only a small number of useful contributions in this direction.

Studies of the weight—usually without any regard for the amount of food consumed—have come to varying results of purely empirical value. The most commonly accepted one is that during an acute psychosis the weight is apt to decrease. When it begins to increase together with an improvement of the mental symptoms, the general prognosis seems much more favorable than when increase in weight is not accompanied by mental improvement.

A point of general pathological interest is the question whether the changes in metabolism are directly influenced by the central nervous system. For the decision of this question we have no sufficient data and we need more than mere determinations of weight.

The studies of the *urine* suffer from being incomplete or not correlated accurately enough with the other facts of metabolism which would help us form an accurate idea of the bearings of the results. They usually run along lines of interest in general medicine, and only a few are part of accurate studies of metabolism.

There exist studies on *albuminuria*. In this country they were intended to show how frequent disease of the kidneys was in the insane (Bondurant). Frequently delicate methods were used which are not applied in other fields of medicine, and with this the finer feeling of proportion concerning the importance of the findings was

disturbed in favor of excessive findings in the insane. Albuminuria with a definite relation to mental disorders has been noted transitorily and parallel with the degree of the mental symptoms in a number of cases of delirium acutum, mania, delirium tremens, paralytic fits, etc., where "nothing" pointed to nephritis. In these conditions an influence from the brain akin to that in experimental albuminuria has been claimed. But a different explanation would be as probable, viz., that in the height of the disease the otherwise resistive kidneys may be influenced by the conditions which bring about the much more striking brain symptoms. This would be a more cautious expression than that of influence of the brain on the kidneys, used by Köppen.

Albumosuria or propeptonuria has been found in mania (Pilcz) and also in connection with albuminuria by others. The bearing of its occurrence is not sufficiently established.

Peptonuria is not sufficiently clear in its bearing, but it has been found oftener in the insane than in other patients, outside of conditions of putrid or suppurative processes, perhaps owing to the increase of output of motor energy.

Glycosuria has been described occasionally, but has only casuistic importance.

Acetonuria and diaceturia have been traced to febrile, diabetic, and cachectic conditions and to states of underfeeding. They have been found frequently in paralysis, in melancholia, in the beginning of acute psychoses, such as amentia, delirium tremens, postepileptic deliria, etc. Their bearing is not certain.

Ptomaïns and leucomaïns would seem to be important factors in view of the fashionable auto-intoxication theories. The effects of injection of the urine of patients into animals are very difficult to interpret and have not led to any safe results, contrary to what is claimed especially by French investigators. Whether the Naegeli-Klingmann reaction of certain algæ to diluted blood serum of various types of patients will lead to more fortunate results remains to be seen.

Of late some empirical efforts of influencing metabolism have been introduced in the form of thyroid feeding and of serum treatment. The results and the methods as such belong more properly in the chapter of therapeutics, as most of the reports do not fulfil the conditions of careful experiments.

Pathological Anatomy.—The second large field of symptomatology is pathological anatomy. It is the fact that just in this direction relatively little has been achieved and that the little is difficult to understand, a result that gives food to the idea that "there is no pathology of insanity as yet." Under the sign of the cell concept, pathology has become, to perhaps an undue extent, a science of what is met with in the dead. To be sure, ordinary pathology also occupies itself with the living; but chiefly along lines which lead to an understanding of definite pathological lesions which we see fully only in autopsies, while the insane reach in death a stage of existence in which they are but slightly if at all distinguishable from the remains of the sound. Apart from profound idiocy, general paralysis, senile and organic dementia, and a few conditions which entail peculiar attitudes and consecutive deformities, the majority of the bodies of the insane furnish at the present stage of knowledge no data which would answer satisfactorily the question: What distinguished the patient from a person with the same physical ailments but sound mind? or the question put to me once after a medico-legal autopsy by the foreman of a jury, And what did you find on the mind?

Pathological anatomy must have been a field in which the physician had a right to seek refuge from the bewildering flood of dogmatism concerning the mental symptoms. It has become fully as speculative though as that of the dynamic and psychological side of man, and the assumptions of histopathologists who compounded their theories out of "tangible" material and data derived from anatomy, have certainly been fully as great and bewildering as the ones compounded by those psychologically inspired.

Normal neurophysiology and neurohistology have gone through very interesting and instructive phases during the last century. The memory of the up-and-down movements of dogmata should cure us of exalted expectations as to their maturity as exclusive guides and starting-points. The senseless use made of hyperæmia and anæmia of the nervous system for the purpose of explanation of pathological states, the endless misinterpretation of artefacts in histology, the shifting of the actual function between nerve cells, nerve fibres, and even the neuroglia—all this should caution us. It is not within the scope of the topic allotted to me to say what can be considered the safe data which had best be taken over into the new century. A sketch of some of the fundamental concepts is given in my "Critical Review of the Data and Methods of Modern Neurology," *Jour. of Comp. Neurology*, vol. viii., 3 and 4, and a summary of "Morbid Conditions of the Nerve Cells" in Robertson's "Pathology of Mental Diseases," and in *Brain*, vol. xxii., pp. 204–327.

For didactic purposes the make-up of the nervous system has been reduced to schematic diagrams the importance of which is apt to be overrated, and has probably been overrated in that unparalleled popularization of neurology which we have experienced during the last ten years. Neurology has been revolutionized by the neurone concept; but the new structure does not hold in its most popular form. Serious attacks call for a return to that which is actually established after the dissipations in neurone-retraction theories and the like. Developmental and pathological facts in connection with simple histology furnish laws of *growth* and *trophism* of the nervous system. With reference to growth and trophism, we know something like "neurones"; but the *dynamic* (physiological) and psychic series of data is not traced to individual neurones yet, and much more likely is referable to whole *sets* of histological "elements." Parts of the morphological series have been prematurely correlated with parts of the functional series of facts, and this has led to the fetichism of memory cells, perception cells, etc., and to rash correlations of appearances of nerve cells, etc., with functional states. We have not arrived at a stage yet when we might give a correct and exhaustive description of the nature and happenings of the apparatus of biological plasticity, the nervous system, in concise statements of the "neurone" and its life. A "psychiatry of the neurone" is probably a preposterous notion, and a pathology of the neurone apt to be one-sided, and missing very important facts of neuropathology which can be grasped only if we speak of the nervous system as a *tissue*. The recognition of this fact in more than one way keeps us above the contest for and against the neurone theory and we are less in danger of obstructing our way by preconceived dogmatic ideas. To go on without a realization of the poor foundation of mere dogma would probably add to the disappointments of the last four years.

The nervous tissues are constituted of the derivates of the epiblast (nerve elements, non-differentiated cells, and neuroglia), and the mesoblastic vascular outfit, sheaths (meninges), and membranes of support. Moreover, the various parts are exceedingly heterogeneous both in the general texture and in the structure of the constituent parts, far more so than holds for any other organ of the body. If there were not a remarkable constancy from individual to individual in the anatomical distribution of the tissue types and characteristic tissue elements, the very differentiation of the various parts would make it almost useless and even hopeless to try and enter into great details in a general pathology of the nervous system. It becomes almost of necessity a *special pathology* of the differentiated parts; and, indeed, this is what is furnished us by well-established neurology—the analysis of effects of special lesions in special parts with their immediate and remote consequences are the bulk of what is of value in pathological anatomy of the nervous system to-day.

In the first line we find the study of "secondary degeneration" of fibres; in some more studious investigators there is also a desire to know something about the fate of cell bodies belonging to the degenerating tracts. Further, we have good data on certain primary systemic degenerations. On inflammatory and other tissue changes beyond the minute local consequences of embolism and hemorrhage and injuries, and perhaps certain changes in myelitis and encephalitis, but little has become common property and safe knowledge of facts.

As soon as general problems arise, such as the pathological anatomy of paralysis agitans, we are led into a great deal of uncertainty which is shown to exist owing to the imperfect foundations for a general pathology, in this special case, owing to an imperfect knowledge of the senile nervous system. And in the sphere of mental diseases we find ourselves even more at sea because changes are found and would seem to be of importance which have always been passed over by the neuropathology of the level of the Weigert-Pàl stain. Delicate newer methods have opened new paths and made great claims, and now it seems that they have not as yet been tried sufficiently in non-insane material to allow of a generally accepted discrimination of what conditions are normal or trivial, and which ones are pathological and how they are produced. So much has been made of findings with the delicate recent methods that the "pathological anatomy" related to psychopathology would be forced to be to a great extent a critical review of the results of some special methods, principally those of the type of Nissl's stain, those of the type of the Marchi reaction, those of the neuroglia stains, and to some extent those of the metallic impregnations (Golgi, Robertson, etc.). They have proved very helpful in the study of neuropathology for the types of myelitis and of multiple sclerosis and other disorders of fairly definite standing; not to mention the consequences of embolism, thrombosis, and hemorrhage, and within the field of psychiatry general paralysis and senile dementia, topics which are to be treated in the articles on special pathology, and to which we shall refer only as far as the principles are involved. But where they dealt with conditions found in ordinary "non-organic" psychoses, the details lacked the large frame found in general paralysis, multiple sclerosis, etc., and the judgment of the investigators was frequently at sea on account of the absence of a suitable material for comparison.

After all, the data obtained by the inspection of the brain as a whole, especially its weight and the condition of the membranes, have not been altogether eclipsed by what the recent methods of staining reveal. Moreover, it might be of importance for a real "psychopathology" to add a study of the condition of the non-nervous organs which participate in the "mental diseases," if such material did really exist.

Several text-books of mental diseases attempt to give an anatomical and anatomo-pathological outline, but these chapters are only rarely helpful. They limit themselves frequently to the cortex, and to the things which appeal to the alienist, and often fail to show a good sense of proportion to pathological concepts in general. It seems quite obvious that for a pathological anatomy of the nervous system all possible disorders, whether or not accompanied by mental diseases, must first be subjected to a sufficient study before the special cases which show mental disorders can be expected to furnish a sufficient material for comparison. Such a general pathology and *general pathological anatomy of the nervous system* are growing but slowly. To-day, the best and most helpful books on mental disorders happen to be those which speak least in terms of anatomy, and in this lies a very strong hint.

Averse to generalizations concerning the "neurone," we must leave the description of cell types and their reaction to the articles on nervous histology and general pathology of the nervous system. Since most of the data are in the stage of "uncorrelated facts," they must certainly be known to one working on the pathological anatomy of mental disorders, but are of no help yet in a general pathology of insanity. We give in the following a concise statement of what is likely to be a topic of discussion in *general pathological anatomy in connection with the insane.*

We do not know any disorders of nerve cells which could be considered specific for any special mental disorder, with perhaps the only exception of what may be seen in senility and idiocy. In idiocy, Hammarberg has demonstrated underdevelopment of cortical cells both in form and number; in senility we meet with usually pigmentary atrophy.

A great share of other disorders described in the literature are terminal affections, not directly connected with that which may represent the actual foundation of the psychosis *per se.* Clinically, too, we know that the dying insane patient is no longer merely "insane," but both physically and mentally his condition is different from the classical stage of the disease. What will be said here of cell changes and tissue changes is said without any reference to clinical correlations beyond what is explicitly stated.

With febrile agonal coma (as in pneumonia, etc.), we have learned to associate the "*acute alteration*" (of which Hoch gives a description in the *Journ. of Insanity,* vol. liv., p. 604), and practically identical with what the experiment of overheating produces: reduction of the stainable lumps into dust and more or less complete dissolution, diffuse stainability of the cell plasma, so that the dendrites and the axone show for an unusually long distance, even in cells and cell parts which show almost no stainable substance normally; the nucleus is either not changed or is swollen slightly, or less frequently diminished in size. Among the chains of the linin net, especially along the nuclear membrane and near the nucleolus, there appears a greater number of deeply stainable and fairly large grains reaching the size of "accessory nucleoli," but more deeply stainable by hæmatoxylin than the nucleolus itself. In the nuclei in which a reduction in size has occurred these grains are more numerous; the nuclei become darker and finally they assume a diffuse stain, and the nuclear membrane is apt to disappear. At the same time the nucleolus may grow larger and paler. In some of these cases the nuclei may show a fairly regular distribution of very sharp dots, while the membrane is hardly visible and the nuclear sap is delicately stained. These forms with darkening and diminution of size of the nucleus and usually crumbly decay of the cell body belong to the so-called *grave alteration,* which appears as a rule alone, *i.e.,* distinct from acute alteration, and impresses one as a much more serious decay almost amounting to liquefaction. It resembles certain forms of post-mortem alteration, but must be upheld as an ante-mortem product, as it has been observed in fresh autopsies of general paralysis and tuberculous meningitis (Hoch). This and the acute alteration cannot demand more than general neurological interest, as they both seem to be terminal appearances not directly associated with what is usually included among mental diseases. Another incidental alteration is the rarefaction; a reduction of stainable substance without affection of the non-stainable plasma, visible, especially in some cases of senility and general paralysis, in the motor cells of the medulla and cord and in some cortical types, with or without pigmentary changes.

A further change of almost mechanical importance is that produced by œdema, and described by Hoch* as "*shrinkage.*" It affects especially the smallest and medium-sized pyramids of the cortex and hardly ever the largest elements. The nucleus becomes homogeneous and dark and loses its membrane; the cell body gets a honeycomb or crumbly structure, the cell outline and nucleus are distorted and shrunken, whereas in some of the smallest pyramids the cell body becomes distended, vesicular.†

* "Nerve-Cell Changes in Somatic Diseases." The American Journal of Insanity, vol. lv., page 231.

† See also Alzheimer: "Zur pathologischen Anatomie der Hirnrinde." Monatsschrift für Psychiatrie und Neurologie, Bd. ii., S. 96.

A neurologically more fundamental alteration is the one which accompanies various types of myelin decay, analogous to what happens when a nerve fibre is cut near enough the cell body. This condition is extensively present in "*central neuritis,*" which is fully described in *Brain* (Part xciii., 1901). In the cases described there, the typical *axonal alteration* of all the largest cortical and other elements was present as a systemic parenchymatous affection and in fibre sets belonging to them the Marchi reaction showed decay of the myelin sheaths. As a terminal affection the condition deserves notice. It is summarized as follows:

1. Eight times in two hundred autopsies in which a microscopic inspection of the cortex took place a condition of bilateral changes of the nature of the axonal reaction in practically all the Betz cells was observed, accompanied by the same changes in other cell types and, where this was looked for, by decay of the medullary sheaths of some of the corresponding sets of fibres, whereas the characteristic disease of the tissue of general paralysis (gliosis, vascular infiltration, etc.), was absent. An extensive examination of large areas of the brain in three cases shows the existence of a partially systemic but widely distributed and strikingly symmetrical parenchymatous alteration of numerous nerve elements, chiefly of the cortico-thalamic connections of the motor area, the auditory radiation, the forceps, the pyramids, the fillet, the restiform body, and, to a lesser degree, the posterior columns of the cord, the intersegmental elements, and the segmental efferent motor elements. The change is that of axonal reaction in many of the large-cell types and decay of the myelin sheaths. Instead of the long descriptive term "partially systemic parenchymatous degeneration principally of the central nervous system," we propose the expression "central neuritis" in the sense of an equivalent of parenchymatous neuritis, but mainly of central distribution.

2. This alteration has been found to occur in peculiar forms of end stages of depressive disorders, near or after the climacteric period, alcoholico-senile and alcoholico-phthisical cachectic states, idiocy, and perhaps also general paralysis (Turner's case). Ordinary infectious and cachectic states do not, however, appear to form an important link in the causes.

3. Clinically, the symptoms are rather vague: after a course in which there is no suspicion of organic disorder there appear, more or less suddenly, difficulty of locomotion, increasing weakness for co-ordinated movements, rigidity and at times jactitation of the limbs, and disorders of the reflexes, often together with diarrhœa and occasional febrile fluctuations; the mental condition in this terminal episode is either that of anxious perplexed agitation, delirium, or stupor, similar to a protracted delirium tremens. The nature of the disorder appears to be an equivalent of the general type of parenchymatous nerve-cell alterations, but, in distinction from the well-known infectious and toxic types of "polyneuritis," of pre-eminently central distribution.

It is by no means certain what the real connection is between the myelin decay and the cell alteration. There are in my collection a number of cases in which it would seem that there is a beginning decay of the stainable lumps between nucleus and axonal process, or all around the nucleus with an occasional full-fledged axonal alteration (this was the case in a patient who committed suicide in an attack of hypochondriacal melancholia), but without decay of myelin sheaths. The temptation is great to take these cases as initial forms and the "central neuritis" as the typical ones; but there are good reasons against such easy explanations.

The wide distribution of the change requires studies of most parts of the nervous system and warns us against a premature limitation of the attention of the alienist to the cerebral cortex only.

Intermediate between these chiefly parenchymatous alterations of nerve elements, and the prototype of real tissue disorders, such as constitute the classical picture of general paralysis, there are a few conditions, in which the *neuroglia* plays the important part. Alzheimer has described in melancholia the existence of fibril production in the neuroglia cells of the deeper cortical layers, where the average brain shows no fibrils. He has also shown that in the cases of acute insanity which pass by without defect, such as conditions of exhaustion and delirium of fever, the glia remains essentially passive, even in very grave cases. In psychoses of intoxication, the reaction of the neuroglia is more active; even in very acute cases this can be seen by numerous mitoses, rather than by formation of fibrils for which there may be no time. In the processes of deterioration there is a decided increase of glia with growth of fibrils but apparently limited to certain parts of the cortex only. In general paralysis the well-known overgrowth of neuroglia is general; in senile dementia it shows, moreover, a tendency toward appearance in foci depending on vascular distribution; in epilepsy it implicates chiefly the surface.

We can largely corroborate these data, but we must add that excessive proliferations of neuroglia (free nuclei or satellites) around nerve cells especially of the deeper layers of the cortex have been described frequently as effects of over-heating, starvation, as phagocytosis, etc., and that it would be unwise to accept Alzheimer's first distinction before those matters have been subjected to experimental tests. In my description of this condition (*Journ. of Insanity,* vol. lii., pp. 246–249) I still shared the error that these free nuclei might be leucocytes. I cannot see more in it than a reaction to nutritive anomalies, as is especially shown by Lubimow's experiment on starving dogs.

This condition leads over to *reactions of the tissue as a whole* and finds its prototype in the alterations in general paralysis, to be treated elsewhere. Suffice it to say that it probably represents two types of pathological changes. The more or less systemic degeneration, especially of terminations of fibres or at least their parts rather remote from the cell body; types of this are the frequent tabetiform degenerations of the posterior columns of the cord, and, in part, the degeneration of the lateral columns. The latter and the diffuse degenerations which Starlinger demonstrated with the Marchi method stand midway between this primary (toxic?) degeneration and the degenerations which depend far more obviously on disorders of the tissues as a whole, with early changes in the vessels, the neuroglia, the intercellular substance and many cells, and a general disturbance of the normal orderly stratification and orientation of the elements.

All degenerative disorders, if at least they last long enough, lead to conditions which can be used as *macroscopic indices of lesions* in various parts of the nervous system: thickening of the membranous and vascular apparatus and of the envelopes of the brain generally, and reduction of the mass of brain substance in the shape of general or localized atrophy. The conditions of the scalp, calvaria, dura, and pia are described in Robertson's "Pathology of Mental Diseases," with such detail and care that the reader can be referred to that treatise with the remark that the whole complex of data can at best be a fairly useful index in autopsies, but is not promising of fundamental clews from the point of view of true general pathology of insanity. It is too much of the nature of a side product, but as such a strikingly faithful reagent, which must not be taken too lightly. So far, however, next to nothing that would throw any definite light on the nature of mental derangements and of the actual degenerative processes that are at work in the nervous system, has been gleaned from the study of the minute anatomy of the *membranes.* It seems that where the disorders of the membranes occur, whether with or without mental derangement (as in simple chronic alcoholism), they are always of essentially the same type. The condition of *hemorrhagic membranes of the dura* also is not different from what is seen in chronic alcoholism, or ordinary senility, trauma, or cachexia, although it occurs more frequently in senile dementia, general paralysis, alcoholic insanity, and epilepsy, a product of retrogressive changes combined with reactive overgrowth of endothelia of the

dura, involvement and new formation of blood-vessels and organization of extravasations, and perhaps oftener connected with trauma than is usually admitted.

The condition of the *skull* is very variable. The most frequent anomalies are senile dystrophies, especially irregular or strand-like hyperostoses of the frontal bones with increased adhesion of the dura. There are no sufficient statistics available concerning these findings in those not insane.

A topic usually included in the pathological anatomy of mental diseases is the *othæmatoma*. That cystic degeneration of the ear cartilage is more frequent in cachectic insane persons cannot be denied. But a careful observation of the cases under my observation has shown the hæmatoma to be invariably of traumatic origin, and I have not seen a case yet in which trauma was excluded. Consequently it has little bearing on the general pathology of insanity.

The work of Robertson and that of Berkley contain extensive discussions of the *vascular lesions* in insanity. This is a chapter of pathology of the vascular apparatus in general, and apart from special disorders such as atheromatosis and the syphilitic and metasyphilitic and traumatic alterations of but little correlated value. Here again we feel the great lack of material derived from non-insane individuals for comparison, which must form the foundation. A prolonged study of these matters has made me so strongly convinced that the problems must come from the study of the living and not from the dead, that I consider a discussion of these details a waste of space and time for all who do not work on them specially.

There remain the gleanings from the nervous system in the directions of *general conformation, weight, and chemistry*. The former shares the verdict of what has been said concerning the stigmata of abnormal development. The beginnings made by Mickle, meritorious as they are as collection of facts, will be of little comparative value until we know something of familial comparability of brains, and of the determining factors in the growth of specific varieties of fissures of the brain, or, at least, until the material for comparison supplies sufficient data concerning the constitutional value of the "normal" bearers. This is so difficult and laborious a task that it will probably not be attacked very soon.

A similar statement must be made concerning the weights of brains. From the largest series of brains (that of Boyd, who compares 2,086 brains from a London workhouse with 725 brains of insane persons), Donaldson concludes that the insane are not a class with a characteristic brain weight. It is true that in senile dementia and in general paralysis a striking loss of weight is noted, and that the loss refers probably more to the frontal lobes than to other parts. But these are matters of special pathology of these two disorders. Personally I do not expect anything from the summary statements, especially those made concerning the whole promiscuous mass of "the other psychoses." Before generalization comes, even if made on such excellent observations as Forel's and Meynert's, there should be more discrimination among the mental disorders and the distribution of lesions, and some sort of a possibility to know what amount of brain matter is to be expected in an individual of definite size, age, and attainments. It is possible that Bolton's measurements of the layers of the cortex in the insane and an application of Hammarberg's cell counts will prove more fruitful.

Concerning specific gravity and even chemistry, little is available that is not much better expressed by easier methods of observation of abnormalities. There is one noteworthy series of studies on the presence of cholin in the cerebrospinal fluid, by Halliburton and Mott, which shows cholin to be in proportion with the amount of myelin decay and which may give valuable *intra-vitam* evidence in time.

This general statement of what the anatomical symptomatology of insanity furnishes in the line of data for a general pathology of insanity must appear negative to the one who adheres to the common belief that pathological *anatomy* is more than a possible help for pathology, or even the "pathology" itself. To uproot this superstition will be one of the first tasks of this century. It is to be hoped that with better insight the idea will disappear that the temporary fruitlessness of mere pathological anatomy implies the verdict that there is no pathology of insanity as yet. What makes pathological anatomy so valuable in many other disease groups is that the field was ready to give a frame for distinctions; and these distinctions, already foreshadowed by the clinical evidence, happened to be more easily demonstrated anatomically. But where anatomy furnishes fewer distinctions than *intra-vitam* observation does, pathology must penetrate the most promising points with relative resignation concerning anatomy. This does not imply that anatomical research is hopeless. It certainly must be carried further on the ground of a general pathology of the nervous system, and with guidance from clinical psychiatry, as an essential part of psychiatric phenomenology.

The Malpighian question "ubi est morbus," *i.e.*, where is the point of attack of the disease, urges us to look for greater clearness in the question of correlation of function with special mechanisms of the nervous system. In this direction the pathology of aphasia and of focal lesions will be of great help, and it is possible that Flechsig's data concerning the growth and maturation of the fore-brain will prove of use. On a material of forty-eight hemispheres of twenty-eight brains from the seventh month of gestation to the age of fifteen months, he has ascertained the time of medullation in various parts of the cortex (*Neurolog. Centralblatt*, November, 1898, vol. xvii., pp. 977–996) and found forty areas which can be distinguished by the phenomena of growth. It remains a task of the future to show how great the bearing of data of growth will prove to be for data of function.

For some time to come, psychiatry will have to work on the "special pathology" of the disorders that it meets. To show that this is possible is the purpose of this article; to bear it out, the task of the special articles. A more helpful general pathology depends on more accurate data of special pathology. *Adolf Meyer.*

V. INSANITY: GENERAL SYMPTOMATOLOGY.—The symptomatology of insanity is as varied in its expression as mind itself. Definitions of insanity in court or elsewhere are unsatisfactory for the reason that conciseness and clearness are wellnigh impracticable. Insanity is not a specific entity; it is rather an ever-varying symptom complex corresponding to many diverse underlying disease processes. It is extremely difficult to frame a simple brief definition sufficiently comprehensive to include the great variety of mental and physical phenomena encountered in the various types of mental disease.

Briefly, insanity may be said to be a prolonged departure from the individual's normal method of thinking, feeling, and acting due to functional or organic disturbance of some portion of the encephalon. Not only does the pathological process within the cerebrum induce well-marked psychic phenomena, but certain physical changes are quite constant accompaniments of the disease. The persistence or permanence of these physical changes again depends upon whether the psychosis follows functional or organic brain conditions. The symptomatology of insanity then may be classified into two large divisions: I. The psychical. II. The physical or somatic.

It is also necessary to bear in mind that there are two large divisions of mental unsoundness, viz.: (*a*) Idiopathic insanity or the insanity of the non-degenerate, or, as Macpherson characterizes it, the insanity of the slightly degenerate, for in nearly every case of idiopathic insanity the presumption is strong that there must be an hereditary predisposition; and (*b*) the insanity of the pronouncedly degenerate. In the former class are found the periodic insanities such as acute mania and acute melancholia occurring in adolescent and adult life. In the latter division are found the congenitally deficient, the imbeciles, and the idiots and those moral degenerates whose vices and crimes often startle society. The insanity of the non-degenerate

rarely ever occurs until after puberty, and sometimes does not develop until the stress of adult life acts as an exciting cause. The insanity of the degenerate, on the other hand, appears in those whose minds were never normally developed owing to congenital structural brain defects. There are therefore insanities that are functional in their origin, and still other insanities whose underlying cause is some congenital or acquired structural brain defect.

The custom at one time prevailed of classifying insanity according to its etiology, at another time according to its symptomatology, especially when the symptoms represented a changed state of the feelings. Thus there was homicidal insanity, suicidal insanity, impulsive insanity, and so on ad infinitum. Morbid exaggeration of the feelings afforded a basis of classification and a nomenclature founded on the prevailing emotion resulted. Depression long continued was called melancholia, prolonged exhilaration mania. It is obvious that changes in the states of the feelings are too evanescent to be made the basis of a system of classification. Under such a method every new symptom or group of symptoms, every change in the condition of the emotions sufficed to establish a species of insanity.

Again, the etiological basis of classification is misleading because identical symptoms frequently follow causes that are entirely dissimilar, and because the symptoms of one supposed type of disease so encroach upon those of another variety that the clinical characters are not consistent and the result is confusing to the mind of the student. Moreover, in many instances the causation is so obscure and unascertainable as to render a nomenclature founded upon etiological factors alone impracticable.

Recent progress in psycho-pathology, in the histology of the central nervous system, has modified our conception of the psychoses and materially changed our classification. The tendency is toward simplification. A single species of insanity takes the place of several under the older classification. The acute psychoses, melancholia and mania, are considered to be one and the same disease. Kraepelin's proposition to make the tendency of the underlying disease process, whether toward recovery or dementia, a criterion of the character of the psychosis is certainly helpful. His masterful description and separation of *dementia precox* from the varieties of mania, melancholia, and katatonia under whose symptomatology it had so long been obscured, his demonstration of its natural history, thereby proving that its various phases are but stages of one underlying disease process, is a most valuable contribution to psychiatry. Finally, the *neuron theory*, though still a theory, is sufficiently well sustained to illumine much that was dark and uncertain.

In the following brief account of the symptomatology of insanity it is proposed *first* to outline the psychic phenomena that accompany disordered mentality, whether of functional or of organic origin, and *secondly* to portray as briefly as possible the physical changes associated with the disease, including not only those physical symptoms consequent upon disordered function but also those more permanent physical stigmata the result of transmitted long-continued structural defect.

I. Psychical Symptoms.

Dynamic disturbance, either psychical or physical or both, is a distinguishing feature of all the psychoses. This is manifested in four ways: 1. Excitement; 2. Depression; 3. Enfeeblement; 4. Confusion. These four symptoms represent a disturbance in the general activities of the nervous system and are witnessed in both the psychical and the physical spheres.

1. *Excitement.*—States of excitement are accompanied by a heightened activity of all the nervous elements. There occurs as a result of this stimulation a marked feeling of exaltation, excessive egoism, intellectual activity proceeding to incoherence of thought and speech. There is an increased motorial activity of which we shall speak later. There are also hyperæsthesiæ of all the special senses. Oftentimes there is marked acuteness of hearing, sight, and touch, which tends to heighten the intellectual and motor activities, and render the perception remarkably acute. In states of excitement the degree of stimulation may be so slight as to be scarcely perceptible, showing itself possibly in a slightly increased egoism or in an unusual loquacity with a diminished capacity of holding the attention to individual subjects or to customary pursuits, or it may extend to complete incoherence and wild furious outbursts of psychical and physical excitement. Excitement receives its fullest illustration in the psychosis called mania, but maniacal symptoms may appear at any time in the course of other forms of mental disease, as in paresis, in dementia præcox, and in the insanities of degeneration.

The neuron theory offers a plausible explanation of the condition. Diminished resistance with increased irritability of the nervous elements permits a flooding of the sensorium with innumerable sensory impressions and a consequent unrestrained outflow of nervous activity over all the efferent routes. This pathological release of nervous energy differs from normal activity in that all mental and physical action is more or less purposeless. There is a manifest inability on the part of the patient to hold the attention to definite subjects; the power to inhibit irrelevant lines of thought is so weakened or lost that discursiveness is a result. It follows that the patient laboring under morbid nervous excitement is able to accomplish little. Although busy from morning to night and frequently far into the night such individuals produce no tangible results. In its milder forms the patient is so excessively loquacious, so officious and so fussily active as to be exceedingly troublesome. In extreme states excited patients may become destructive, absolutely incapable of connected thought, and in advanced and oftentimes fatal stages consciousness becomes obscured and automatic, aimless muscular movements alone remain. These latter symptoms are usually an indication that the nervous elements within the higher cerebral levels are exhausted, their functions suspended, and uninhibited cell action within the lower levels has full sway.

2. *Depression.*—Depression is exactly the reverse of excitement. The two conditions cannot exist at the same time in the same person, although they may alternate with each other. Depression is attended with a diminished metabolism in the nervous elements. There is reduced excitability and increased resistance of the cerebral neurons. Intellectual and physical activity are both diminished. Sensory impressions are reduced in number and owing to the poorer conduction fewer sensory stimuli reach the higher brain. In states of depression the patient lives within a limited world of his own. He sees and hears less than the normal individual by reason of the high resistance to the transmission of nerve energy over either the afferent or the efferent routes. There is therefore morbid concentration upon a few impressions, an inability to escape from dominant lines of thought and to project the attention upon new or even habitual subjects. Moreover, intellectual action is painful. Psychalgia in states of depression is as characteristic as is exaltation in conditions of excitement. The patient loses hope and courage. Mole-hills seem mountains. Abasement of the ego is pathognomonic.

In extreme stages of depression as in excitement the functions of the nervous elements within the higher cerebral levels may become partially suspended. In these conditions consciousness may be more or less obscured; automatic movements and even stupor may prevail. While excitability of the nervous elements is lowered in states of depression, perversions of special sensation and local neuralgias are of quite frequent occurrence and serve to intensify the psychalgia.

In the evolution of the acute functional psychoses depression and excitement are not now considered to be specific disease entities but parts of one and the same disease process. In the natural history of these psychoses melancholia or depression is considered to precede excitement, and in those cases in which excitement is the prevailing feature a brief initial stage of depression is said to

occur. As long ago as 1865 Sankey declared that "mania and melancholia are simply stages of one disease," and called attention to the fact that Griesinger, Guislain, and Neumann had all advanced the opinion that classification based on the expression of the emotions alone was unscientific.

It is a fact that the two conditions, excitement and depression, both representing dynamic disturbances of such wide diversity, do succeed each other with such ease and frequency in the same person that one is constrained to feel that the underlying pathological condition is the same, only attended with varying emotional expression. Identical causes may lead to depression or excitement, or to both states in succession. Whether depression will be brief and excitement long, or vice versa, will depend upon whether there are increased irritability and diminished resistance of the neurons or whether there are lowered irritability and heightened resistance. There is a psychical reason why depression should precede excitement in the acute psychoses. Before alienation is fairly established, prior to the actual development of delusion and other intellectual derangement, the patient himself realizes the fact that something is wrong. Consciousness, being neither clouded nor exalted, discloses to the patient the fact that he neither thinks with his accustomed vigor nor feels the same as in health. Discomfort, dissatisfaction, induces mental distress which, though transient in many instances, is nevertheless real and constitutes the preliminary psychalgia characteristic of all the acute functional psychoses.

3. *Enfeeblement*—mental weakness or dementia—is, as its name indicates, a reduction of all the mental faculties from their normal vigor. There is diminished metabolism in the nervous elements. Retarded conduction along the various neural paths is an early symptom. There is a blunting of sensation. Fewer sensory impressions reach the higher brain through the different afferent routes, and those sensations that are transmitted from the periphery are so delayed in their passage as to make the interval between the external impression and realization in consciousness noticeable to the observer. Oftentimes several seconds elapse before a stimulation at the periphery reaches the higher brain levels. In like manner the passage of nervous energy over the efferent routes is similarly delayed. The mandates of the will are slowly and feebly obeyed. Reflexes are retarded or obscured. The intellectual processes are slow. The attention, the will, and especially the reasoning power are all diminished.

Mental enfeeblement is usually secondary to some antecedent psychosis. Generally speaking, all forms of mental disease that do not recover terminate in varying degrees of dementia. Cases of acute primary dementia so called are usually preceded by antecedent psychical disturbance, or occur in individuals possessing an hereditarily neurotic constitution. Ordinarily mental enfeeblement occurs either as a result of congenital defect (imbecility, idiocy) or it is the termination of an acute functional psychosis, or finally it may be secondary to structural brain change the result of traumatism, arteriosclerosis, embolism, apoplexy, and the like.

The diminished irritability and retarded conduction of the nervous elements in dementia differ from similar conditions met with in depression. In dementia there is an actual degeneration of the neural paths, while in melancholia there is merely a temporary suspension due to functional disturbance. In dementia the cell structure within the higher brain levels undergoes deterioration. Consequently the lower levels are left to act without direction. Automatic action and the more purely vegetative functions of the nervous system supplant intelligent purposive action. Marked trophic and peripheral motor symptoms occur; to these reference will be made later.

Mental enfeeblement may succeed acute functional insanity quite soon and progress very rapidly, or it may appear tardily after many attacks and progress only to a slight degree, there remaining stationary for many years. Its early appearance after an acute functional psychosis and its rapid progression to extreme mental reduction depend upon constitutional idiosyncrasy. In some individuals the nerve centres resist this tendency to secondary degeneration, while in others they succumb quickly.

One characteristic of the mental reduction of dementia is that it does not affect the mental faculties equally. Quite frequently some faculties are intact while others are noticeably damaged. Mental reduction usually occurs in the inverse order of mental evolution. Those faculties that are the last to appear in the natural process of growth are very apt to be the first to deteriorate in the dementing psychoses; moral and volitional stability show evidence of weakening before there is marked change in consciousness and perception which represent an earlier stage in the process of mental evolution.

4. *Confusion.*—Prominent among the dynamic disturbances of the central nervous organism in insanity is confusion. In health the nervous system is a delicately adjusted mechanism composed of numerous individual elements functionally associated with each other in groups. These groups are still further associated with others even more remote, and all are in a state of equilibration. Excessive action in one area encounters resistance from adjacent or remoter tracts with which it has been associated, so that the entire mechanism works harmoniously toward a given end. In states of depression there is increased resistance with diminished irritability of these nervous elements; in states of excitement there are diminished resistance and increased irritability; in states of enfeeblement, diminished irritability and conduction due to general deterioration of cell structure. In confusional states there is a dissociation of the different nervous tracts. Limited areas are cut out as it were. Neural pathways that in health were intimately associated are no longer correlated. The result is the utmost confusion in thought. A certain degree of confusion characterizes every variety of insanity. In confusional insanity there is profounder disturbance.

There is not only an incapacity for what Berkley calls the "power of serial thought," but there is more complete interruption of the intelligence. There may be exaltation and depression alternating with unusual rapidity in the same case, transient hallucinations, delusions very imperfectly developed, obscuration of the personality and consciousness, and finally automatism.

It is now generally recognized that the confusional insanities are all of toxic origin. The toxins of alcohol, of puerperal and other fevers, of septicæmia and those that are developed from auto-intoxication are supposed to have a special affinity for the nervous system. Macpherson contends that toxins may even have the power to "select certain physiological neuron groups for attack." One group may be stimulated, another depressed. He concludes: "In normal conditions excessive functionating of one group of neurons is physiologically interfered with by the inhibiting influence of opposing nerve currents, but where this, owing to the irregular pathological nature of the process, is impossible, there result confusion of thought, disturbance or loss of the idea of personality, uncertain and impulsive action, and many other anomalies depending upon the intensity of the poisoning of the cortical cells, and the area of the elements involved" ("Mental Affections," Macpherson). Homicide and suicide are occasionally attempted by persons in the toxic confusional state following alcoholism. Amnesia, submergence of the normal personality, and automatism usually characterize such acts. An analogous condition is met with in the *epileptic state.*

In each one of the conditions just outlined the ideation is fundamentally different. In states of excitement there is exaltation of the ego,—a feeling of expansion predominates. In states of depression there is abasement of the ego,—painful ideation prevails. In states of enfeeblement there is deficiency of ideation varying from the slightest impairment to the profoundest dementia according to the extent of the central cell deterioration. In confusional states there is disconnection of thought, a blending of all the symptoms encountered in the three preceding condi-

tions due to the toxic interruption of function in certain brain areas.

Among the early noticeable and most persistent symptoms of acute or chronic insanity are those special disorders of the intellect—delusions, hallucinations, and illusions.

Delusions are so universally prevalent in nearly every species of insanity, are so persistent and striking a feature in the majority of cases that in the past and occasionally at present they are regarded as a proper legal test of the disease. In 1800, at the trial of Hadfield, Mr. Erskine proposed the substitution of delusion for Lord Hale's absurd wild-beast test of insanity. He said: "Delusions, where there is no frenzy or raving madness, is the true character of insanity." This, however, like many other legal tests, is fallacious, for many cases of alienation exist in which no delusions can be detected.

In the early stages of mania and melancholia and in incipient dementia there may appear marked disturbance of the feelings, failure of judgment, and inability to appreciate the proper relations of things, but no evidence whatever of delusion. Such patients are manifestly elated or depressed, they may be extremely active in business, undertaking too many schemes, making foolish purchases or sales contrary to their previous good judgment; they may in countless ways manifest an inability to adjust themselves to the conditions of their environment, and yet on the closest examination fail to disclose a single delusion. These cases are often puzzling to the general practitioner and the laity generally. They may be very troublesome and even dangerous and require the restraints of a hospital, but their coherence of thought and speech, the absence of delusion, and their general good appearance tend to obscure the real condition which is one of failure of the higher mental processes. Notwithstanding the untrustworthiness of delusions alone as a test of insanity and responsibility, they are still in the majority of cases a striking evidence of intellectual derangement. When proven in court they are always convincing to judge and jury.

Delusion may be said to be a belief in some person or something that is impossible in the nature of things or that is inconsistent with the circumstances of the person who believes it. A man believes his legs are made of glass, is afraid to walk, run, or jump for fear he would break them. This would be a belief in something impossible in the very nature of things. Or a poor, ignorant laborer believes himself to be president of the United States, which would be a belief entirely inconsistent with his circumstances and condition in life. The difference, if any, between an insane delusion and a sane erroneous belief is that the sane person can be convinced of the falsity of his perception, while no amount of argument can persuade the insane man of the error of his delusive conceptions. As well might you attempt to dispel the pain from an inflammatory joint by argument as to induce the insane patient to give up his delusions. Regis insists that "there is not, properly speaking, any essential difference" between delusive conceptions of the insane and the errors of the sane, and that the delusion is separated from mere error only by its causes and consequences, which give it a pathological character never possessed by the other" (E. Regis, "Practical Manual of Mental Medicine").

Delusions are the direct product of insane reasoning. They are false conceptions arising within the disordered mind of the patient either as a result of inco-ordinated central cell activity or in obedience to perverted peripheral sensory impressions. The patient, as a result of his impaired reasoning and without the slightest evidence, believes that his dearest relative is his worst enemy, or a sensation of numbness and prickling in the hand leads him to infer that some one is charging him with electricity from a battery.

Delusions always partake of the character of the prevailing emotion. In states of excitement expansiveness characterizes the delusions. There will be delusions of wealth, great power, and a general feeling of elation. In depression exactly the reverse occurs. The delusions will be of painful character; there will be belief in specific imaginary acts of wrong-doing that are to be followed by terrible temporal and future punishments. Delusions are of infinite variety and so numerous as almost to defy enumeration. They may be persistent or evanescent. The longer they last the less likely they are to disappear and the surer is the evidence of permanent mental derangement. The systematizing of delusions, the development of a few persistent false beliefs grouping themselves around one or more central dominating conceptions, are evidences of an underlying brain disturbance and consequent chronic incurable insanity. Thus a delusive belief in enemies who are making every effort to defeat personal success in life, this delusion crystallizing itself around a central conception of self-importance and worth entirely inconsistent with the facts, is symptomatic of paranoia.

Hallucinations.—Hallucinations are false perceptions projected outward and referred to some one of the peripheral organs of special sense. They correspond with delusions in that they originate within the person's mind and owe their origin to disturbed activities of the neurons and a consequent inability on the part of the patient to correct the wrong impressions. They differ from delusions in that they always concern some one of the special senses. The brief definition of Ball is sufficiently explanatory: "Hallucination is sensation without an object." A person sees smoke issuing from the register in the wall when there is nothing of the sort; he hears a voice addressing him when there is no voice to be heard. The accepted theory of the origin of hallucinations is that they are partly psychical and partly physical. They may entirely originate within the mind, or they may be initiated by morbid peripheral activity in some one of the special sense tracts. Dissociation of the cerebral nerve cells prevents erroneous impressions from being corrected, and the result is a false perception referred to the peripheral organ in which the stimulation originated. Hallucinations like delusions are usually influenced by the character of the prevailing emotion. The exhilarated patient hears voices giving him information of pleasant import, or has beatific visions; the depressed patient hears words of ill omen or has visions of a painful, distressing character. The paranoiac who is convinced that enemies are conspiring against him to injure him and prevent his success in life usually hears the voices of his foes, can actually recognize what they say, or smell and taste the poisons they have placed in his path. Hallucinations serve to intensify delusions and contribute to the psychic pain or pleasure of the patient. In the evolution of insanity delusions appear first; hallucinations are a later symptom, which would seem to indicate that they are chiefly psychical in their origin and owe their existence to the dissociation of neural pathways.

Illusions.—There is little real difference between hallucination and illusion, both are deceptions of the special senses. Strictly speaking, an illusion is a wrongly interpreted sensation. A man sees a tree with its branches swaying in the wind, his disordered mind interprets the spectacle to be a many-armed giant waving its arms and hands. There is an actual sensation which is perverted by the imagination to mean something entirely different. Owing to the dissociated action of the cerebral areas impressions received in the higher brain through the channels of special sense cannot be corrected. They remain as persistent evidences of the dominant beliefs of the patient. As in delusion and hallucination the character of the illusion will be modified by the prevailing character of the disturbance, whether it is of exhilaration or depression.

THE WILL.—Impairment of volition is an early psychic symptom of insanity. The will is not a specific entity; it is rather a complex resultant of past experiences and idea associations modified, stimulated, and directed by education, environment, and hereditary predisposition. On the purely physical side the will is nothing more than the reflex motor realization of the strongest sensation. Owing to the intimate association of volitional selection

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with consciousness, by which we are made aware of a power within us to choose between one or more courses of action, we say that a sane man possesses a free will power. We say that he *can* decide between several courses of action submitted to him. By reason of this power he is said to be responsible for his acts. No matter how arbitrary the law of association of ideas may be nor how rigidly such associations may dominate the will we do feel that every sane man has the power within him of selection. This power is weakened in insanity, and is one of the very earliest symptoms of mental disease. The knowledge of right and wrong may exist, but "the power to choose the right and avoid the wrong" may be impaired or wholly lost. The status of the will power is, therefore, a most important question in all criminal cases in which insanity is suspected or urged as a defence for crime. In all such cases the real test of responsibility is not a knowledge of right and wrong, but the power to choose between two courses of action. If a person has not such power by reason of insanity, then his act is the product of his disease and he is not responsible. The general practitioner who ordinarily sees cases of insanity in their inception before they come under the observation of the specialist, should be familiar with the importance of volitional impairment in the insane and its relation to knowledge of right and wrong.

The fact is, insanity and irresponsibility, or at least modified responsibility, are nearly if not quite synonymous. Certainly it is true that no form of insanity exists in which there is not modified responsibility. Not only does the insane man reason from wrong data, but the power to see things in their proper relationship is impaired. His mental perspective is distorted. The inability to make rational comparisons and to exercise the power of choice are the earliest symptoms of mental disease. The capacity to distinguish right from wrong, either in the abstract or in any particular case, is not lost until the insanity is far advanced. Such loss is one of the later manifestations of pronounced functional and organic brain disturbance. To state arbitrarily, therefore, that responsibility depends upon a knowledge of right and wrong is decidedly unscientific.

The theory that partial insanity necessarily or usually implies responsibility is based upon fallacious reasoning. One error, as has been so often stated by alienists, lies in the fact that partial insanity is not so limited in its effect on mental operations as the lay mind conceives it to be. Limited delusions and isolated morbid ideas may be only a small portion of the symptomatology. They are noticeable phenomena, but must not be considered to represent all that is morbid. Because the insane person manifests only one or two delusions, talks coherently and intelligently, and transacts business correctly, it does not follow that his mind is sound on all other relationships outside the one or two prominent delusions that he may exhibit. Their unfortunate possessor is usually damaged in all the higher mental processes, such as the judgment and the moral perceptions, and, particularly, in the exercise of the will power.

While apparently sane on all other topics and able to talk connectedly on every-day matters and transact his routine business, he may be so dominated by certain prevailing ideas as to be wholly unable to resist certain acts, because in his own disordered mind they are justified by the facts in his individual life. These are the insane people who are most dangerous. It is not the turbulent maniac, full of incoherence and noisy destructiveness, but the quiet secretive paranoiac, who moves around amongst people in his daily avocations, who may spread destruction in his path.

The man who is, as the lawyers say, "partially" insane may know that his act is wrong and a punishable offence, but in his disordered reasoning he will argue that the facts justify the deed and it will be impossible to convince him to the contrary. So distorted is his perception of the proper relations of things, so overwhelmingly exaggerated is his own morbid egoism, that he will feel impressed with the justice and absolute necessity of his act and will usually assert that, when others know all, his conduct will be sustained. The reasoning of the partially insane mind is nearly always utterly inconsistent. But the laity usually commit the blunder of expecting and insisting that the partially insane mind will reason exactly as does the sane mind.

In every case of suspected insanity especial effort should be made to ascertain whether the criminal act is the result of morbid reasoning or is the product of mental disease. If the act is the outgrowth of disordered reasoning, if the man's judgment is so enfeebled that he cannot properly estimate the natural relations of things, if his will power is so enfeebled that he cannot resist the powerful pressure from within that impels him to the deed, then the act may be said to be the product of his disease and is not criminal, no matter how clearly he may understand the nature and quality of the act, whether right or wrong in the eyes of the law, or how coherently and intelligently he may converse on ordinary topics, and plan and effect an ingenious escape from detection.

The ruling of Chief Justice Doe in the famous New Hampshire case of The State *vs.* Pike has acquired an international reputation because of its manifest conformity with clinical and pathological facts. Judge Doe decided that there is no legal test of insanity: each case must be decided on its own merits. The basic facts are that insanity is a mental disease; the product of mental disease cannot be a crime; tests of mental disease are matters of fact, and whether the defendant has a disease and whether his act is the product of that disease is a question of fact for the jury to consider.

MEMORY.—Memory like will is not an individual entity, a specific faculty existing by itself. There is organic memory and psychological memory. Organic memory is simply the organization of functional activities in certain neural pathways. Such memory is subconscious. Psychological memory is more complex. It is organic memory plus consciousness. Every activity within the lower centres that is associated with cell activity in the higher brain is undoubtedly accompanied by a registration in consciousness which will be fleeting or permanent according to the intensity and duration of the corresponding metabolism in the supreme centres.

In insanity psychological or conscious memory will be variously affected. In the acute psychoses the functionating of those higher centres that are identified with mentality and consciousness may be so intense that a rigid recollection of all that has transpired during the illness will be preserved after the attack is over. Or dissociation of cortical areas may be so marked that little or no recollection is preserved. In all those mental diseases in which the structural cell integrity of the higher brain is affected memory will be weakened according to the extent of the deterioration. In the different varieties of dementia, in paresis, in senile insanity amnesia is a striking symptom and in its progressive increase marks the advancing steps of the disease process. In senile dementia particularly is the retrograde failure of memory noticeable. In this disease those events of later life which have received the briefest organized registration are the first to disappear from memory, and the occurrences and associations of early life which are represented by a longer and more complete organic registration are the last to disappear.

Amnesia characterizes all subconscious states. All diseased conditions associated with automatism are invariably followed by an almost total amnesia. Post-epileptic automatism or the so-called *epileptic state* affords a good illustration. Many crimes have been committed by epileptics while in this condition. Undoubtedly such individuals at the time of committing these acts are subconscious, and as the higher brain centres have no participation whatever with the lower levels from which they are temporarily dissociated no registration in consciousness occurs and there is no psychological memory of the act.

In acute melancholia cerebral dissociation occasionally

is so complete, functional activity is so rigidly restricted to limited cortical areas that consciousness, if it exists at all, exists in such a weak form that amnesia results. The writer recollects one case of ineffectual suicide in which the patient made a good recovery but could never recall the act. In another case of melancholia the mother drowned her only daughter, a little girl to whom she was passionately devoted, told some one of the act shortly after its performance, and then sank into a partially stuporose state. After recovery she could not recall the occurrence. Such cases are especially interesting, as they seem to indicate that there may be a retroactive amnesia. Events are feebly registered in consciousness, partially recalled, and then completely obliterated from the mind. These cases also demonstrate how purposive acts may still be attended with amnesia. As Ribot says: "There is no contradiction in admitting that a nervous state, sufficient to determine certain acts, may be insufficient to awaken consciousness" ("Diseases of Memory," Ribot).

THE EMOTIONS.—The emotions or feelings seem to be almost a part of ourselves so readily are they elicited by the slightest provocation. When analyzed the feelings are found to arrange themselves in two large classes: those that are expansive and those that are depressing. The former are the basis of pleasure. The latter underlie sadness, pain. Among the sane the feelings are under the control of the individual to a greater or less extent. The extent of the control depends largely on personal idiosyncrasy. Among normal individuals we notice the greatest diversity in the expression of the feelings. Some are always quiet and undemonstrative, others excitable, bounding from one extreme to the other. The former are called phlegmatic, the latter emotional. There is a happy mean difficult of definition, yet readily recognizable. Excessive emotionalism implies lack of equipoise and such persons are said to be *hysterical*, implying by that term feeble self-control.

Insanity is characterized by weakened inhibition. The emotions are emphasized, and the patient makes few and ineffectual attempts toward restraining their expression. All those feelings that are the outgrowth of the two great classes of emotion, pleasure and pain, receive constant expression in insanity. Affection, hate, jealousy, envy, revenge, and innumerable feelings are exhibited by the insane, and attempts at suppression and concealment are the exception. All these varying emotions are intimately identified with action. The acts of the insane are often instigated by the overwhelming and uninhibited stress of the emotions.

Whatever opposes individual desire is painful, and whatever assists the accomplishment of our ultimate purposes is pleasurable. In the various phases of insanity the ego is depressed or exalted by the character of the ideation. The maniacal person has confidence in his own superiority, he is sure of success, schemes cannot arise too rapidly for his competent disposal. He is elated and hopeful. On the other hand the melancholiac has lost all hope. His cherished plans are not realized, the failure in physical health and strength incapacitates him for sustained mental and manual work and confirms his belief in his own incompetency. In the maniacal patient, in the early stages of paresis there is exaltation of the ego; in the melancholiac there is abasement of the ego. In the paranoiac there may be feelings of depression, but for a somewhat different reason than in the melancholiac. The paranoiac has primarily unbounded egoism. He feels that his real merit is not recognized and that his plans do not meet with success because of the determined and malignant opposition of those who are jealous of his fancied ability.

This imagined opposition, coupled with the fact of non-success and non-recognition by the world, awakens feelings of intense displeasure and pain. By constant brooding over his failure in life, which is really the result of incompetency and not of unrecognized merit, his first feelings of depression are, by virtue of his primary all-overpowering egoism, transferred into feelings of suspicion, then of hate, fear, and desire for revenge. So the paranoiac, who begins with a state of overweening egoism, merges into depression, passes from that to feelings of suspicion, then to fear, and finally to the bitterest sort of hatred. In this latter state of the feelings he is ready for revenge. Nothing short of homicide can satisfy the overwhelming sense of injustice with which he feels he has been treated. Could the innermost feelings of such men as Guiteau and Prendergast be dissected and spread before us for observation the network of mingled emotions of pride, egoism, hatred, jealousy, and the like would be a revelation and go far toward convincing us that such unfortunate creatures are in a maelstrom of emotion impelling them on with resistless violence.

IMPULSIONS (*Imperative Conceptions, Fixed and Insistent Ideas, Obsessions*).—Disturbances of the will and the emotions are closely related to the not uncommon symptom of impulsions known also by the other synonyms above mentioned. Ideas obtrude themselves in consciousness, meet with feeble or absolutely no resistance, and are then realized in acts which are as varied as the ideas they represent. Impulsiveness characterizes all the acts of the insane, may even be a striking idiosyncrasy of some sane individuals. Many persons of ability and mental integrity are impelled by a certain inherent quality of mind to act hastily on the spur of the moment and without the thought, delay, and reflection that are associated with a mature judgment. Children are notoriously impulsive. They seek instantaneous gratification of their desires, not always with due regard to their own best ultimate interests. Arrived at maturer years, however, the child who develops normally exercises reflection and judgment and the impulsive action of an earlier period yields to the deliberative and conservative conduct of adult life.

The forms of insanity in which dementia is not far advanced are characterized by an impulsiveness and a weakness of inhibition that is as striking a feature as are the similar conditions in childhood. Feeble inhibition, imperfect exercise of the will are prominent symptoms of insanity, and play an important part in the genesis of imperative conceptions. Macpherson's explanation of the pathology of obsessions is certainly plausible. Dissociated action of the neurons is the underlying pathological condition. Certain neuron groups, he argues, for some reason become highly resistive, then the discharge of currents modified by these particular groups seeks an outlet through other, though limited, channels. For this very reason the discharge is all the more intense, and the oftener it is repeated through the newer routes the more easy and persistent does its manifestation become. If this mechanical explanation is correct, it is easy to understand how ideas representing the limited and dissociated action of certain cortical areas are projected with great violence into the individual consciousness. The will power which depends upon the normal associative action of all the neuron groups is limited or so reduced as to be ineffectual, and the ideas acquire an intensity and persistency that seek immediate gratification in approximate action. Imperative ideas are accompanied by marked emotional disturbance which intensifies their persistency. The startling abruptness, the utter irrelevancy, the entire absence of any rational cause for the existence of these insistent ideas are clinical evidence of their mechanical origin in neuron dissociation.

However we may explain the mechanical origin of imperative conceptions it is a fact that they are of very frequent occurrence among the chronic insane, especially in the hereditary and degenerative types. In nearly every instance they are associated with a weakening of the will power. However much the patient may desire to banish these ideas from his mind he is utterly unable to do so, and usually is compelled against his will to yield to the appropriate action which they so insistently demand. Such impulsive acts are innumerable, and as varied as thought itself.

At one time it was the fashion to classify insanity into groups according to the character of the imperative conception. There were misophobia, folie du doute, kleptomania, pyromania, and many other species. Such

a classification by symptoms is extremely confusing. Every new obsession becomes a new species of insanity, and when occurring in the same person necessitates a change of diagnosis, while in reality the underlying disease process in all such cases is the same. While impulsiveness, emotionalism, weakening of the will power are all prominent features in the symptomatology of insanity, obsessions undoubtedly represent a specific pathological process. They arise subconsciously, have no associative relationship with other ideas, enter the domain of consciousness unbidden, awaken the most positive emotions, and finally by their very persistency compel their realization in conduct against every possible effort of the will. Individuals with a vicious heredity, those who possess a neurotic constitution as the result of either direct heredity or some degenerative process, the hysterical and the neurasthenic, are favorable subjects for the development of obsessions. Such individuals oftentimes realize the absurdity and even the moral obliquity of the impulsion, but seem powerless to resist its domination. Sometimes it is an impulse to repeat a certain word or phrase, again to touch certain objects with the hand or foot, or it may even be an overwhelming impulse to homicide or suicide. The patient may be startled and frightened at the unexpected suddenness of a conception which seems thrust upon his consciousness without reason and without his bidding; it may be an idea against which his whole moral nature may rebel. Quite frequently such persons realize their helplessness and beg to be restrained before they yield and commit some act fraught with danger to themselves or others. The underlying disease process in all such cases is serious. The prognosis is grave, for the symptom is usually the expression of a degenerative condition. So frequently are obsessions met with in the hereditarily neurotic temperament that they are often regarded as psychic stigmata of degeneracy.

Impulsions may be of great medico-legal importance. Occurring as they often do in those who are intellectually coherent and intelligent, it is difficult for one not familiar with their origin and development to realize their arbitrary involuntary character. Many obsessions are wholly harmless, such as the fear of contamination, the touching of objects, the doubting mania; but others lead to the perpetration of criminal acts, such as the impulse to steal, to set fire to property, even to suicide and homicide. While purely impulsive insanity as a defence for crime should be investigated with the utmost care, it is well to remember that when such attacks do occur in individuals possessing neurotic heredity and unstable mentality there may be such a weakening of the will power as to render them quite irresponsible for their acts.

Perturbations and Perversions of the Moral Sense.—Maudsley calls the moral sense a "function of organization." There can be little doubt that the moral sense is the accumulated product of the slow acquisition of ages of human experience, aided by hereditary transmission. Originating in the remote primeval past as a utilitarian expedient for the welfare of families and tribes, this sense of right and wrong has through countless centuries of experience and religious revelation become a thoroughly organized function. From being the product of a narrow and selfish utilitarianism the moral sense is slowly progressing toward a higher, more unselfish, altruistic plane. As might be expected, this latest and most unstable psychical acquisition is one of the first to disintegrate upon the appearance of either functional or structural disturbance of the brain. Whatever comes last in the process of evolution is the first to deteriorate in the retrograde changes of devolution.

Imperfection of the moral sense appears as the result of congenital deficiency, or it may be the product of functional or organic brain disease occurring in adult life. Congenital moral defect is one of the stigmata of degeneracy. In the normal individual the moral faculty does not attain to its full growth until mature years are reached. The moral development of the individual is in a way an epitome of its development in the race. The child is selfish, seeks self-gratification, and does not have that strong regard for the feelings of others that we consider the ideal condition of later years. Even in the development of the normal child much depends on environment, teaching, and associates. Given a good heredity and environment, and the normal child very early evinces a proper regard for the rights of others, a sentiment of right and wrong, and a desire to reciprocate favors. The accumulated acquisitions of the past are not lost, and in the psychical development of the normal child the moral sense soon shows the advantages of good birth and training. On the other hand, the degenerate child, the offspring of neurotic ancestry, may disclose an utter incapacity for moral development. Such children are selfish, have no regard for the rights and feelings of others, oftentimes delight in the torture of animals or the abuse of younger and feebler children than themselves. Arrived at mature years they are erotic, oftentimes yield to beastly sensuality, and are naturally criminal by instinct in all their desires. The idiot and the imbecile often manifest this imperfection of the moral sense which becomes a true stigma of their degeneracy. Occasionally there is encountered one of those moral monstrosities in whom there is a bright, keen intellectual development but without any evidence whatever of moral sense. Such individuals, by reason of their cunning, their ready wit and perception, are able to make quite a fair advancement in life, but usually sooner or later their vices bring them into the hands of the law. E. H. Rulloff was a notorious example of this class. Jesse Pomeroy, who early disclosed his degeneracy in the torturing of young children, has shown quite a little intellectual capacity without any accompanying moral sensibility.

Turning from those individuals whose moral imperfections are the stigmata of their degeneracy, we may glance at those whose early life was one of normal development. When such persons become insane, the moral sense manifests some change at an early stage of the disease. In nearly every case of insanity there is marked displacement of the ego. There is exaltation or abasement; self-concentration is a prominent symptom in acute and chronic insanity. With such distortion of the ego there quite naturally follows a selfishness that leads the patient to dwell on personal feelings and ends rather than on the consideration of others. Hence it follows that the insane are very apt to disregard the feelings of those who are nearest and dearest to them, they often become suspicious and abusive of those who have given them no reason for offence. Quite frequently such patients will commit all sorts of depredations on the rights of those who have incurred their unreasonable hatred. So far lost do they become to a sense of right and wrong that they may even take life itself. It is well to bear in mind, however, that knowledge of right and wrong and of the nature and quality of a criminal act may be retained long after the will power to refrain from committing the offence is lost. Particularly is this true of the paranoiac and the subjects of systematized delusional insanity. In these cases the power of inhibition, of making a choice between two courses of action in which the feelings are strongly enlisted, is impaired long before the moral judgment is destroyed.

As might be expected, the insane in whom there is marked structural brain impairment show striking failure in the moral sense. This is especially noticeable in paresis and quite frequently in senile and secondary dementia. Quite often moral lapses in individuals, who have lived blameless and correct lives in the past, are the only evidence of incipient brain degeneration. A weakening of the moral sense is not uncommonly seen in the exhilarated phase of alternating insanity, or in attacks of recurrent mania. Sometimes patients, during the intervals between the attacks, are exemplary in every way, but with the beginning of the excitement and before it is even noticeable they become erotic and so lose their moral perception as to gratify their passion. Upon recovery such lapses from virtue give them the keenest feeling of shame and remorse. In one case in the writer's experience, in a young woman, this was the only evidence

of insanity for years. Her conduct was so shameless that in sheer desperation her people had her committed to a hospital for the insane. For two years it was a question whether restraint was legal, so clear were her intellectual faculties. The patient herself continually protested against her detention, claiming that if she chose to live a fast life it was her own affair and no one else had any right to deprive her of liberty for that reason. In about two years from the date of her admission she developed disturbance in the intellectual sphere, becoming incoherent, destructive, and noisy. From that time she has averaged attacks of intellectual confusion once a year. In the interim between the attacks she seems perfectly well. The failure of the moral sense alone at one time, of the intellectual faculties at another, and the frequent association of defects in both the moral and intellectual spheres on still other occasions in the same person are evidences of the unity of mind and its dependence on cerebral cell integrity.

Disturbance of Consciousness, Alterations of Personality.—Consciousness and the personality are physiologically closely related. Consciousness is that state by which the ego is made aware of present and past sensations and impressions. It is constantly changing, being modified by the countless sensations and psychic impressions that are continually flowing in upon the individual mind. By a certain voluntary selective power, that is the inexplicable possession of every normal individual, consciousness can be directed in this or that direction. Irrelevant trains of thought can be excluded and only those conducive to a certain desired end retained in consciousness. This is the power of attention so essential to success in life and so characteristic of a sound and healthy mind. The ego, the personality that is the essential part of ourselves, that part that each one recognizes as his own most characteristic self, and that every one else associates with this or that individual and with no other person, this ego is the complex resultant of all present and past sensations, impressions, and experiences which is recognized by consciousness. Self-consciousness is that power by which we recognize our own immediate existence here and now and identify it with the same individual existence which has passed through definite experiences and associations in the past. Consciousness is the grand inheritance of animal life and serves to distinguish it from plant life. The dawning of consciousness is, as John Fiske says, "one of the most wonderful moments in the history of creation, the foreshadowing of the true life of the soul" (John Fiske, "Destiny of Man").

Consciousness, the power of voluntary conscious attention, and the personality have a close physiological relationship, and for their normal expression depend on the integrity of the neurons. Slight pathological disturbance of the neurons leads to weakening of the power of voluntary conscious attention as well as to alterations of personality. Graver affections of the neurons may lead to actual interruptions of consciousness, to suspension of the normal personality with substitution of automatism, and to a modified personality so unlike the original normal self that it has been called a secondary or subconscious personality. Consciousness is wholly suspended, in sleep, by the influence of drugs, by traumatism, by epilepsy and other conditions. It is partially suspended or interrupted by the functional or organic brain disturbance accompanying insanity.

One of the earliest symptoms of insanity is a weakening of the power of conscious attention. The patient is unable to inhibit irrelevant trains of thought. He neglects his daily advocations, fritters away his time on needless work, or remains so self-centred as entirely to omit the demands of the hour. Oftentimes imperfectly performed work and neglect of necessary details are the first evidences of mental alienation. As the mental disturbance progresses the change in the personality increases. Relatives first and acquaintances later realize a change in the individual. They say he is not the same. He becomes another and a different person. He does not look at things in the same way, he cannot be depended upon to react as formerly to similar influences. It is not always an easy matter to define the exact change. There may be irritability, impulsiveness, or hesitation, incapacity. Among the symptoms of dementia nothing is more noticeable than this gradual reduction of the personality to a simpler entity. In this retrograde metamorphosis consciousness loses its definiteness and in the last stages of the disease becomes all but extinct, leaving a mere subconscious, vegetative existence.

Disturbances and temporary suspensions of consciousness with alterations of personality occur at times. Such cases deserve most careful study not only for their medico-legal importance, but for the reason that they may throw much light on the nature of consciousness and its association with memory and the formation of the normal ego. Consciousness may gradually fade away and lose itself at last in a state of subconsciousness in which automatism is the chief characteristic. This condition is often noticeable in post-epileptic states, in hysteria, in somnambulism, in the confused state following the toxic effects of alcohol, and occasionally succeeds profound nervous and mental shock, or accompanies the acute functional psychoses. Such conditions are recovered from but leave no recollection behind them. During the period the individual may have performed many complicated and at times apparently purposive acts, but on recovery has no remembrance of what he has done. The period is an utter blank to him. While in this subconscious state persons have been known to leave their homes, travel to remote places, and live another life, awakening to their normal consciousness to find themselves in a new and unfamiliar locality with no realization of where they are or how they came to be there. These phenomena deserve further consideration.

The disparity between the spheres of mind and matter is so great that we continually forget that there is a most intimate connection between the two. This connection is, however, so subtle and elusive as to confuse and perplex our studies. It is only when we are confronted with some strange and very unusual psychosis, such as hypnotic trance, transitory amnesic frenzy and the like, that we realize the close relationship between functional activity of the material mechanism and psychic phenomena.

What is the physical basis of consciousness, the obscuring of which plays so prominent a part in these psychoses? Recent physiological research localizes "conscious processes in the cerebral cortex, within which the sensory tracts end and the motor begin." Dr. Jakob also says in this same connection: "Above the reflex arc which is constituted from the two peripheral neurons there is, as it were, a second arc, which is made up of the central motor and sensory neurons together with their connecting pathways in the cerebral cortex. The latter serves for the conduction from a conscious sensation to a voluntarily innervated movement, that is, for the act of the will." Unquestionably the "cortex is the sole organ of consciousness in man."

This being the anatomical substratum of consciousness, what are the physiological conditions that underlie its manifestations? Full, complete consciousness presupposes functional integrity of the cerebral cortex. If this continuity and integrity of functions be interfered with there is very likely to result what Janet has called "a contraction of the field of consciousness." This may amount to almost complete obscuration, or even lead to alteration of the personality. In this way Binet has said that hysterical anæsthesia is really anæsthesia from "lack of consciousness."

It is even possible for normal consciousness to be submerged and dominated, as it were, by a subconscious condition. This subconscious condition with its power to initiate motor processes evidently has an existence and a memory of its own, for it has been successfully recalled by hypnotic suggestion, and thus demonstrated to have had an existence when the normal consciousness was suspended. Integrity of action within the cerebral cortex is thus extremely essential to normal consciousness. This

is in accordance with the teaching of psychology. Professor James says: "We see that the mind is at every stage a theatre of simultaneous possibilities. Consciousness consists in the comparison of these with each other, the selection of some, and the suppression of the rest by the reinforcing and inhibiting agency of attention." Such comparison, selection, reinforcing, and inhibition must have their organic substratum in the countless connecting neural pathways of the cerebral cortex. Normal consciousness depends upon an associative action of these various neural pathways. Consciousness will be obscured when there is defective associative action. Dissociation is the chief pathological factor in all long-continued insanity. Hence reductions of the normal consciousness are a prominent feature in the symptomatology of all advanced insanity.

II. Physical Symptoms.

The physical symptomatology of insanity may be studied under the following heads:

1. Congenital physical malformations,—the physical stigmata of degeneracy.
2. Disturbance of function in the organs of special sense,—the eye, ear, nerves of touch, etc.
3. Disorders of vital function,—sleep, body weight, temperature, respiration, circulation, blood changes, secretions from glandular organs such as sweat glands, salivary glands and kidneys, general nutrition.
4. Disturbance of motility, including exaggerated and diminished reflexes, as well as those voluntary and involuntary muscular movements that are concerned in facial expression and those motorial activities that lead to the countless postures, attitudes, and automatic movements that form so characteristic a feature in the symptomatology of insanity.

1. Various physical malformations may occur in the different portions of the body. The most striking are those affecting the sutures of the skull. There are no deformities that are pathognomonic of insanity. The lower the type of degeneracy the more pronounced the departure from the normal. Asymmetry of the cranium and of the face is a striking feature in low-grade imbeciles and idiots. Arrest of development of the brain leads to a microcephalic skull. Early ossification of the sutures may cause a distorted cranium as seen in the keel-shaped, sugar-loaf shaped, and kidney-shaped heads of certain degenerates. Unequal development of the orbital cavities, and excessive or atrophied growth of the jaws are asymmetrical types quite frequent in persons of degenerate inheritance. The hard palate is variously affected, and usually it is thought that the high-vaulted, gothic-arched, and saddle-shaped palates are a mark of inferiority. Such palates are supposed to represent a retarded development of the brain in the parietal region, resulting in a coming together of the alveolar bodies and a corresponding encroachment on brain growth.

In the special-sense organs anomalies of the ear and hearing are noticeable. Among the insane we find asymmetrical ears, large, atrophied, pointed, or flat. In the degenerate insane and criminals the ears often project from the skull almost at right angles and present a striking appearance when viewed from either front or behind. Double or unilateral deafness is not unfrequently met with as an hereditary defect.

The eyelids are not unfrequently deformed in those of degenerate stock. A short upper eyelid leads to exposure of the sclerotic. A thickening of the eyelid over the inner canthus gives a peculiar Asiatic expression to the eye and has led to the name Mongolian idiot.

Among other physical stigmata may be mentioned scarcity or abundance of hair, especially in unusual situations in either sex. In many insane women of the chronic and incurable class there occurs quite a heavy growth of hair on the chin and upper lip, and sometimes masculinity of voice is present.

The above-mentioned stigmata are not found in the acute curable insane, they are the physical marks of a congenital degeneracy that is usually associated with criminality and imbecility.

2. Disturbance of function in the organs of special sense plays an important part in the symptomatology of insanity. Cutaneous sensibility is very frequently affected. At times there is hyperæsthesia, again anæsthesia or paræsthesia. Regis calls attention to the fact that an important distinction must be made. He says: "It is not usually the tactile sensibility, strictly speaking, that is modified; that which gives us notions of form, direction, consistence, position and resistance of objects, that is commonly intact. What is impaired is the sensibility to physical agents, heat, pain" (E. Regis, "Practical Manual of Mental Medicine"). In many cases a morbid sensation is purely central. A sense conception, originating within, is by its very intensity projected outward and referred to its proper peripheral locality; it is then an hallucination. Such is the force of morbid ideation that no amount of argument can dispel the imagined sensation. In a large number of cases there is undoubtedly a pathological disturbance of the sensory nerves of touch in different portions of the extremities. These are oftentimes wrongly conceived or interpreted by the mind, are very likely modified by the prevailing ideas and emotions, and so become the illusory basis of a delusion. Imperfect circulation in the periphery may lead to a sense of formication, of heat or cold, and such perverted sensations may be misconstrued by the mind to mean electrical shocks from invisible batteries.

The hysterical often have most striking disturbances of tegumental sensation. Local anæsthesias and hyperæsthesias play a very prominent part in the symptomatology of hysteria. Among the insane nothing is more remarkable than the analgesia that occurs in many cases of acute functional insanity, and in nearly every case, to a greater or less degree, of dementia secondary to structural brain disease. In acute mania and melancholia there is oftentimes the greatest insensibility to heat and cold. In the depressed stage of *dementia præcox* the patients are profoundly insensible to what would, under normal conditions, occasion the most exquisite pain. Patients under these conditions often mutilate themselves with ligations, with scissors, needles, and with hot substances and apparently experience little if any real pain. Among demented patients there is very little sensibility to heat or cold. Such patients must be carefully guarded against extremes of heat and cold in the weather, against scalding in bathtubs, for, owing to their universal analgesia, they are unable to protect themselves.

Disturbance of taste not unfrequently occurs in cases of systematized delusional insanity, and especially in patients suffering from acute melancholia. The obstinate constipation and toxæmia following imperfect intestinal digestion may lead to the foul or bitter taste in the mouth which is wrongly interpreted by the mind, but it is also supposable that sensations are imperfectly received at the peripheral terminations of the gustatory nerve and irregularly conducted to the brain. These perversions of function are quite probably the source of many of the hallucinations of the chronic insane.

The olfactory sense is often exalted or depressed, and its perversions are, as in the functional disturbance of the other senses, the starting-point of hallucinations and illusions. The special senses of hearing and vision are perhaps more frequently disturbed than any of the others. In acute mania there is exaltation of functional activity in these special-sense organs. In melancholia there may be perversion of function and illusions as a result. It is not unlikely that the varying blood pressure in the functional psychoses may have much to do with these perversions. The disturbances of sight and hearing soon subside upon either the removal of the toxin from the circulation if it is a case of toxæmia or upon the return of the blood pressure to normal conditions during convalescence.

3. Among the disorders of vital function in the insane none holds a more conspicuous place than insomnia. One of the earliest premonitory symptoms of the acute func-

Insanity.

tional psychoses is sleeplessness. Before the attack is actually declared the patient usually passes days and occasionally weeks of insomnia. Sometimes worriment

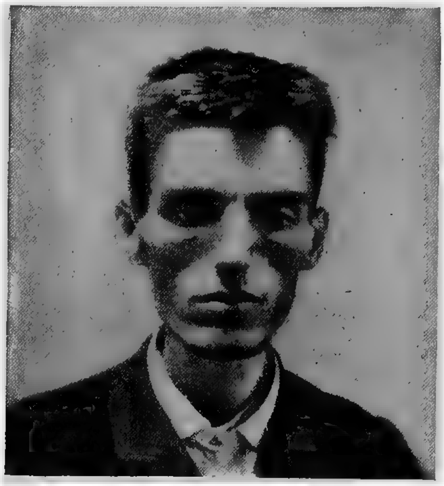

FIG. 2816.—Case XXXIII. Acute Suicidal Melancholia. Taken at height of attack. Trophic alterations, ocular divergence, and self-absorption well marked. (From photograph taken by author.)

over real troubles, financial, domestic, or otherwise; again excessive and protracted mental work induces such a state of cerebral activity that the individual becomes unable to inhibit special lines of thought on which he is engaged and his normal measure of sleep is reduced fully one-half or one-third. This serious interruption of a necessary physiological process leads to a dangerous increase of tissue waste with imperfect repair. The insomnia thus acquired continues after the mentality is impaired, and becomes one of the most serious symptoms which the physician is called upon to treat. Return of normal sleep after a long period of wakefulness is one of the most favorable indications of returning convalescence. After prolonged insomnia associated with mania or melancholia, beginning recovery is ushered in with deep sleep of many hours' duration.

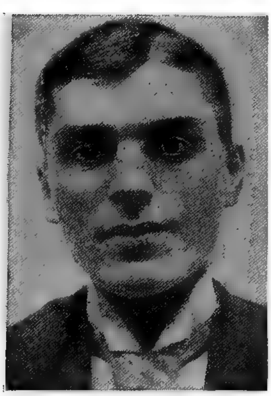

FIG. 2817.—Case XXXIII. Taken five months later. Convalescence established. Healthy ideation and restoration of physical health. (From photograph taken by author.)

The toleration of insomnia is occasionally quite remarkable. Days may pass with only a fragmentary sleep, in all aggregating only a few short hours. Subconscious states usually exhibit few signs of fatigue. Von Hartmann says: "The unconscious does not grow weary; but all conscious mental activity becomes fatigued." Among the chronic insane there is often protracted insomnia, but usually in this class there is an adjustment as well as a compensation. Such patients may remain awake and in a state of noisy activity; but, after twenty-four or forty-eight hours, they sleep soundly for several hours and awake refreshed to renew their excitement and volubility. These cases are exceedingly prone to remain awake nights and sleep days, much to the discomfort of their associates. As a rule the chronic insane are good sleepers, and the wards of a hospital in which these patients are located are as quiet as any private house.

A reduced body weight previous to and during the active stage of the acute psychoses, and a gradual return to normal or supernormal weight during convalescence are matters of common observation in hospitals for the insane. Every well-regulated institution pays very close attention to its dietary, and records from time to time the weights of its patients. As a rule there is marked loss of flesh in the early stages of melancholia. Capricious and irregular eating, imperfect assimilation with scanty repair of tissue waste characterize all these cases. They look thin and sallow, their clothes hang rather than fit their bodies, their eyes look hollow and their cheeks and necks often wear a painfully cadaverous expression owing to the disappearance of fat from the subcutaneous cellular tissue. One of the chief objects of treatment is to secure regular and thorough nutrition with an easily digested and assimilable diet. If necessary, tube feeding and lavage of the stomach are prescribed in order that nutrition may be promoted. During treatment it is the custom in most institutions regularly to weigh such patients, for a progressive increase in weight is a pretty sure indication that improvement is at hand. (For illustration note the marked change in Case XXXIII., Fig. 2816, at the height of the attack, and Fig. 2817, at time of convalescence.) The same observation applies to cases of acute mania, though not with the same constancy as in melancholia (see Case XLII., Fig. 2818, during active stage and Fig. 2819 at time of recovery). In mild mania nutrition is often very good and the body weight but little changed from the normal. In extreme maniacal agitation, however, there is often great reduction in the body weight, and in typhomania emaciation is extreme.

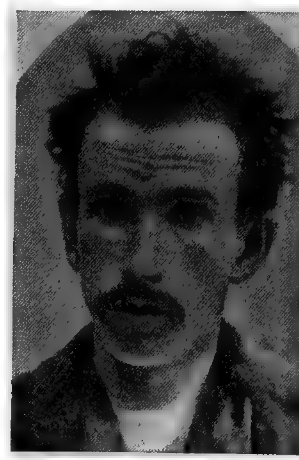

FIG. 2818.—Case XLII. Acute Mania. Taken during active stage. Morbid innervation, trophic alterations, neglect of personal appearance. (From photograph taken by author.)

Among the chronic insane and the demented there is quite frequently a state of good nutrition and increased body weight. After the first and active stage of paresis there is apt to occur a period of hearty eating with good digestion and assimilation and a remarkable increase in weight, followed still later in the third stage by failure of assimilation and reduced weight. In alternating insanity there are reduced weight during the depressed stage and return to normal or excessive weight during the active stage. During the depressed period there seems to occur a slowing of all the vital processes, nutrition among the rest, while in the active stage there is an awakening of all the functions, improved digestion and assimilation seeming to be

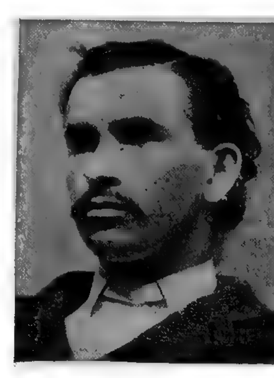

FIG. 2819.—Case XLII. Taken at time of recovery. (From photograph taken by author.)

an expression of the increased metabolism. Of so much importance is this matter of body weight considered that it is customary in hospitals for the insane to record on a clinical chart, by a rising and falling scale, the increase or decrease of weight.

The temperature in insanity is not markedly increased. In some attacks of acute mania there is slight elevation of not usually over 101° or 102° F., at most. In melancholia and in *dementia præcox* there is not only no elevation, but the temperature may be subnormal. In the large number of the chronic insane there is absolutely no change whatever. In paresis and in cases of structural brain deterioration there may be remarkably high elevations of temperature following attacks of embolism, and serous or hemorrhagic effusion. Occasionally in these cases the temperature will range from 104° F. to even 107° F. Such unusual elevations are of serious import and indicate a grave prognosis.

The respiration is not seriously disturbed in insanity. In mania there is little alteration. In melancholia there is apt to be a slower respiration with shallow inspiration, but nothing that can be regarded as especially pathognomonic. In cases of dementia secondary to embolism or to an attack of cerebral apoplexy there may occur a characteristic Cheyne-Stokes respiration with the rhythmical increase of respiratory movements followed by marked decrease. In one case under the writer's observation the rhythmical increase in the respiration was accompanied by a cyclical return of consciousness, which soon subsided as the respiration became slower, and during the period of cessation the patient sank into unconsciousness. This rhythmical ebb and flow of the vital forces continued for some days before death.

The force and frequency of the circulation and the blood pressure among the insane have received careful study. There is a greater frequency of heart disease among the insane than among a corresponding number of sane persons. The frequency of arteriosclerosis in the insane is now a well-recognized pathological fact, and plays a prominent part as an etiological factor in a large proportion of cases of insanity in middle and later life. The muscular walls of the heart are weakened in many cases of chronic insanity, and rupture of that organ is not so very infrequent an occurrence; two cases within one year happened in the writer's experience. A series of sphygmographic examinations were made at the Bethlehem Royal Hospital by Maurice Craig, M.D., and reported in the *Lancet* of June 25th, 1898. The article deserves careful study. Among the conclusions arrived at the following are especially noteworthy: 1. The blood pressure is higher in states of depression, and returns to normal after recovery. 2. It is lower in states of excitement, and returns to normal after recovery from such conditions. 3. The blood pressure tends to fall as the day advances, and hence melancholia cases tend to improve toward afternoon, while mania cases grow more excited. 4. In stuporose states the blood pressure rises. 5. The lowered blood pressure following acute mania is exhaustive in origin, and will remain lowered until its return to normal after recovery. 6. Experiments thus far do not enable one to say that insanity is caused by variations in blood pressure. Such variations do, however, suggest a line of treatment. Thus the feeling of weight and oppression on the vertex is undoubtedly vascular in character, and when the blood pressure is relieved by hydrotherapeutic or medicinal measures the distressing sensations disappear. In short, Dr. Craig's conclusions furnish a strong argument for hydrotherapy in the acute functional psychoses. A very rapid and somewhat weakened pulse is frequently noticeable in cases of melancholia and occasionally in mild mania.

The blood itself has been microscopically examined by different observers. Several experiments have been made to test the bactericidal action of the blood of the insane to determine whether the blood of such persons contain toxic elements not appearing in the blood of the sane. D'Abundo "found the toxicity and bactericidal power of the blood increased in all forms of insanity except in the depressed conditions, in which, on the contrary, it was lessened" (*Journal of Mental Science*, April, 1895). M. Legrain concludes from his study of the subject that the convulsions of paresis are often due to toxicity of the blood. The blood serum is the vehicle of the toxin, and the toxæmia, induced by injections of the blood serum of paretics, reveals itself in symptoms identical with those of uræmia.

Dr. W. Johnson Smyth made a most careful study of the blood and reported his conclusions in the *Journal of Mental Science*, October number, 1890, as follows:

"1. That in insane patients there is a very marked deficiency in hæmoglobin.

"2. That the deficiency is greatest in secondary dementia.

"3. That there is no very marked difference in its amount in melancholia, epilepsy, and general paralysis of the insane, though in the last disease I found very high percentages during the stages of marked exaltation.

"4. That the number of red corpuscles in these insane conditions is below the normal standard.

"5. That the number of red corpuscles is least in secondary dementia.

"That it is greatest in general paralysis of the insane; that the variations in the other diseases are too trivial to attach importance to them."

With reference to the relative proportions of white to red blood corpuscles Dr. Smyth found no variation from the normal. He also concludes that in insanity the blood is usually in a pathological condition, but quite frequently this is a secondary state and not causal to the insanity; he says in "some forms of mental diseases the blood is imperfect *ab initio*, that it fails to supply materials for the growth and development of the brain; whilst that in other forms of mental disease the blood change is secondary to organic disease, and morbid mentality results owing to the inability of the brain of the unstable to resist the influence of its diseased blood supply."

In a recent article by Dr. F. Percival Mackie in the *Journal of Mental Science*, January, 1901, entitled, "Observations on the Condition of the Blood in the Insane, based on One Hundred Examinations," Dr. Mackie draws the following conclusions:

"In looking through the grand averages we cannot help being struck by the slight departure from normal which exists in the blood of insane patients. Though in some cases slight changes are noted with some degree of constancy, yet they are so insignificant that they do not appear to throw any light on the pathology, or give any indication for treatment in any class of cases. When they do occur, there is good reason to suppose that the alteration in the blood state is quite secondary to the mental change; and further, the examination of the blood in the present state of our knowledge is not even an aid to prognosis or diagnosis, as it is in so many diseases."

All the secretions are modified to a greater or less extent by insanity. Ptyalism is a very common symptom in idiocy, imbecility, and cases of chronic dementia. It is often surprising to notice what quantities of saliva may be passed by demented patients. This is occasionally a most troublesome symptom necessitating frequent changing of the clothing or the wearing of rubber bibs. During the waking hours this salivation may be incessant.

The perspiration is variously affected in insanity. In many cases of dementia, melancholia, and *dementia præcox* there is almost entire absence of secretion from the sweat glands. In these patients the skin is dry and scaly, the hair, is brittle, rough, and absolutely free from natural moisture. In other cases there is a cold clammy sweat, due undoubtedly to a relaxed state of the blood-vessels and to feeble circulation. It is a matter of frequent observation that the hands of many insane feel cold and moist and entirely unlike the warm, dry touch of the normal individual. There seems little doubt that a certain peculiar mawkish odor is exhaled from the skin of chronic demented patients. Owing to the lack of healthy muscular tonicity, and the feebleness of the circulation there

is imperfect glandular action in the skin, products of tissue waste are retained rather than eliminated, and a disagreeable odor results. One of the strongest arguments in favor of rain in preference to tub baths for the demented insane is the tonic effect of the shower upon the skin. There is imparted to the latter tissue a glow, the circulation is stimulated, and waste products are removed more effectually than by the poorly applied warm tub bath.

One of the most important glandular secretions is that of the kidneys. The exact relationship of kidney disease and insanity, whether the kidney affection is causal or secondary to the mental disturbance, has long been a subject of discussion. There is no question that the two are quite constantly associated. The following conclusions arrived at by different observers during the past nine years are interesting and deserve careful study.

The toxicity of the urine of the insane has been tested. No very positive results have yet been derived. Dr. George T. Tuttle, of McLean Hospital, after citing Purdy, T. Clifford Allbutt, Dickenson, and Savage, all of whom believe in mental anxiety as a chief cause of kidney disturbance, concludes as follows:

"First. Chronic nephritis is sometimes the cause of mental aberration, which may be called insanity.

"Second. Long-continued anxiety may cause albumin, hyaline, granular, epithelial, and blood casts in the urine, with accompanying œdema in some cases.

"Third. This kidney affection may be temporary, disappearing when the cause is removed, or, the cause persisting too long, may become chronic renal disease.

"Fourth. Contrary to the opinion of many observers, disease of the kidneys is quite common among the insane." ("Kidney Disease in Insanity," by George T. Tuttle, M.D., *American Journal of Insanity*, April, 1892.)

Dr. E. D. Bondurant, of the Alabama Insane Hospital at Tuscaloosa, made a careful analysis of the urine of the insane and recapitulates his collective results in regard to Bright's disease and insanity as follows: "That albumin, together with renal tube casts, can be detected in the urine of more than half the cases of chronic insanity treated in this institution, and in the urine of quite seventy-five per cent. of the cases of recent insanity admitted.

"That a large proportion (not all) of the patients whose renal secretion is thus abnormal exhibit at some time some other evidence of renal disorder.

"That a small percentage, say twenty-five per cent., of those whose urine contains tube casts and albumin present such clinical evidences of nephritis as should enable any competent practitioner of medicine to make the diagnosis of nephritic disease or complication without examination of the urine.

"That seventy-five per cent. of the kidneys examined post mortem show pathological changes.

"And finally, the facts obtained seem to justify the opinion that many of the patients (not all, be it remembered) in whom insanity and nephritis coexist are insane because of the nephritis; *i.e.*, the insanity is one of the mental symptoms of acute or chronic uræmic intoxication." ("Bright's Disease and Insanity," by E. D. Bondurant, M.D., *American Journal of Insanity*, July, 1895.)

In a comparison of sane patients in a general hospital and insane patients in hospitals for the insane Dr. Prout finds a higher percentage showing gross kidney lesions among patients dying in hospitals for the insane than among those dying of general diseases in a general hospital. Dr. Prout considers that an increased elimination of toxic compounds in the urine would naturally lead to structural kidney change, and he considers the increase of kidney lesions found in autopsies on the insane an argument in favor of the autotoxis theory ("Kidney Disease and Insanity," by Thomas P. Prout, *American Journal of Insanity*, January, 1897).

Cleon Melville Hubbard arrives at the following conclusions in regard to the urine of melancholia:

"(1) The amounts of urine and solids are generally diminished, and they usually increase with the patient's improvement.

"(2) The specific gravity is normal.

"(3) The urea and uric acid are, as a rule, diminished.

"(4) The diminution in nitrogenous excretions is due in most cases to a diminished ingestion of proteids, but in some it may possibly result from a lessened absorption of food.

"(5) The ratio of uric acid to urea shows no constant relation to the mental condition." ("A Study of the Excretion of Urea and Uric Acid in Melancholia," by Cleon Melville Hubbard, *American Journal of Insanity*, April, 1898.)

Dr. W. L. Worcester, of the Danvers Insane Hospital, in an article on "The Relations of Renal Diseases to Mental Derangement," arrives at the following conclusions "Renal disease in some degree is very common among the insane, but it is by no means certain that it is very much more common among them than in the population at large at corresponding ages.

"Cases in which insanity is due simply to disease of the kidneys are rather infrequent in hospitals for the insane. Taking the term 'Bright's disease' in its broadest significance, however, it is probably one of the most common causes, if not the most common, of mental derangements."

Dr. Worcester calls attention to the fact that in acute delirium without exception he has found urine "heavily charged with albumin and has contained large quantities of casts." He doubts whether the starting-point of this condition of the urine is in the kidneys. Dr. Worcester still further calls attention to the great prevalence of vascular degeneration as a cause of the mental decay in senile dementia and its association with degeneration of the kidneys and infers that kidney degeneration and senile dementia may have a common cause ("The Relations of Renal Diseases to Mental Derangement." Proceedings of the American Medico-Psychological Association, vol. vi., by W. L. Worcester, M.D., Assistant Physician and Pathologist, Danvers Insane Hospital).

Dr. M. Allen Starr, of New York, believes that among several causes of neurasthenia and melancholia a toxic origin occupies a prominent place. In such cases "the urine is irregular in quantity, at times scanty, of high color and of high specific gravity; at other times profuse, light, and of low specific gravity, and at all times it contains large quantities of indican or indoxyl." Exactly what the toxic agent is Dr. Starr does not say. He says that "indican or indoxyl is the one particular thing found in the urine in varying quantities according to the general condition of the patients, and yet I do not suppose that indican is the active poison" ("Toxic Origin of Neurasthenia and Melancholia," by M. Allen Starr, New York *Medical Record*, May 11, 1901).

The analyses that have come under the writer's own observation give the following results for melancholia: *Quantity* diminished, *specific gravity* diminished, *solids* diminished, *urophain* increased, *urea* diminished, *indican* increased, *uric acid* diminished or increased, *sulphates* diminished, earthy and alkaline phosphates diminished, *albumin* generally absent. From all these observations it may be concluded that in melancholia and neurasthenia there is imperfect elimination from the kidneys of the ordinary waste products of the blood, and that there is impaired intestinal digestion with more or less decomposition of the contents of the intestinal tract. As with the pathological condition of the blood so with the kidney disturbance, it is difficult to say whether these functional irregularities are the cause or the result of the mental disease. The writer inclines to the opinion that in the majority of cases the renal disturbance is secondary to the psychosis, and dependent on the impaired functions of the central nervous system.

4. In disturbances of motility, the reflexes may be exaggerated, diminished, or otherwise modified in different psychoses. In the earlier stages of paresis there are usually exaggerated knee-jerk and ankle clonus, followed by a progressive failure and final disappearance of these

phenomena as the central degeneration advances. As a rule the deep reflexes are diminished in those varieties of insanity in which depression is the prevailing feature, such as melancholia, the stuporose stage of *dementia præcox*, and dementia, and they are exaggerated in those varieties in which activity is a marked symptom, as in mania. The temporary disappearance of the deep reflexes followed by their reappearance in the same patient in different stages of the functional psychoses is an evidence that this symptom alone is not necessarily an indication of organic disease. Absence of the eye reflexes, however, is usually an evidence of organic brain disease, and is most frequently noticed in paresis.

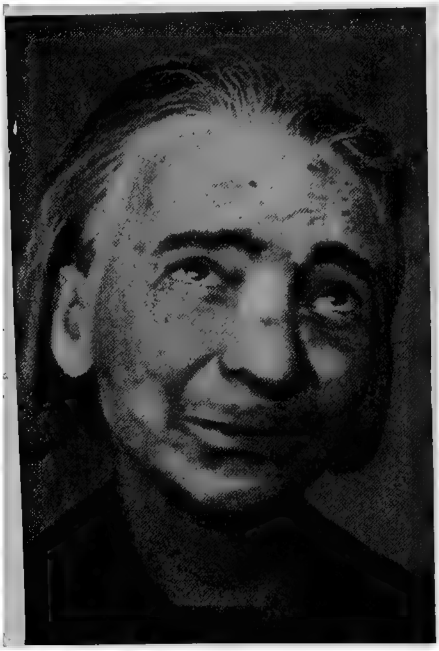

FIG. 2820.—Case XXVII. Chronic Melancholia. Morbid and uninhibited expression of grief. Darwin's "grief muscles" in contracttion producing "horseshoe mark." (From photograph taken by author.)

In hemiplegia the Babinski reflex appears in about seventy per cent. of the cases, according to Drs. Walton and Paul, and is also associated with pyramidal-tract disease.

The most noticeable evidences of disturbed motility are seen in the changed physical expression of the insane. All outward muscular movements, whether of the face, trunk, or extremities, succeed definite functional activity of some portion of the central nervous system. It follows, then, that functional or organic disturbance of the brain in insanity must lead to varying peripheral changes, both those of expression in the countenance and those consisting of peculiarities of gait, posture, and other muscular movements. These changes in physical expression when analyzed resolve themselves under the following heads: I. Impairment of healthy inhibition, which is so frequently associated with insanity, and one result of which is weakening of the faculty of attention. II. Excessive or defective nerve-muscular activity of an involuntary character, dependent upon morbid irritation or degeneration of the cerebral structure.

I. In health the inhibitory function is exercised in a twofold manner: First, in checking irrelevant trains of thought, repressing whatever is impertinent to the subject engaging the attention; and secondly, in checking certain muscular movements which, though they naturally follow the stimulations which have preceded them, still, for the time being and with other objects in view, are undesirable and out of place.

In the early development of insanity one of the first symptoms to attract the notice of the friends, and to arouse their suspicions of mental disturbance, is a manifest inability on the part of the patient to concentrate his attention. This will declare itself in various ways. The patient becomes inaccurate. If a mechanic, he either accomplishes less work or is careless; if in business, he makes frequent mistakes and fails to fulfil important obligations. All this inaccuracy and omission of detail are due to varying degrees of self-abstraction. The patient has lost the power of successfully inhibiting the fleeting thoughts or suspicions which crowd his mind and which supplant the ideas that immediately concern his daily work and life.

The asylum workshop affords an excellent illustration. Here you may study inhibitory incapacity in every stage of development. A stranger enters the room and probably half of the patients will cease working, some will arise from their seats, and possibly one or more will walk about the newcomer, looking him over inquisitively and either talking to themselves or to the visitor. And in what a scattered and desultory way is much of the work performed! Evidently ideas irrelevant to the occupation in hand absorb and divert the attention of these diseased minds into other channels. In just the proportion that the individual possesses inhibitory capacity, to just that extent does he seem capable of performing successful and intelligent work.

Bearing in mind, then, that weakening of healthy inhibition is one of the first results of insanity, we find this impairment of the inhibitory capacity manifested in the physical, and particularly the facial, expression of the insane in two ways:

1. There is inability to control the movements of the facial muscles. The insane make few attempts at concealing the facial expression of their feelings. With them impaired inhibitory power interferes with that slight volitional control which we possess over those facial movements that habitually follow certain emotions. In the familiar language of daily life the insane *look* very much as they *feel*, and their attempts at concealing their real emotions are few and unsuccessful.

2. For the same reason that there is impaired inhibition, there is inability to concentrate the attention, the result of which is an expression of self-absorption quite peculiar and characteristic of the disease.

FIG. 2821.—Case LV. Acute Melancholia. Marked and characteristic innervation of Darwin's "grief muscles." Intense motor disturbance. (From photograph taken by author.)

The insane patient makes few and ineffectual attempts at disguising the feelings which oppress him. The conflicting emotions by which he is disturbed are reflected through the various motor tracts to the face, and as a result we may often read the character of the delusions which preoccupy the mind. Thus the expression of the countenance in acute melancholia is generally quite characteristic of a depressed state of the feelings; and what is especially noteworthy is the fact that this diseased expression is far more intense than would be the expression of similar emotions

in the same individual in health. Impaired inhibition does not exercise any restraining influence upon the countenance, and, whether alone or in the presence of others, the melancholiac presents the furrowed brow, the anxious and distressed expression about the eyes and mouth that are characteristic of these especial emotions, whether they proceed from natural or morbid causes. The only difference is that the normal manifestation of grief is modified by healthy inhibition, while morbid sorrow is persistent, intense, and not subject to outward restraint.

FIG. 2822.—Case X. Alternating Insanity. Exhilarated stage.

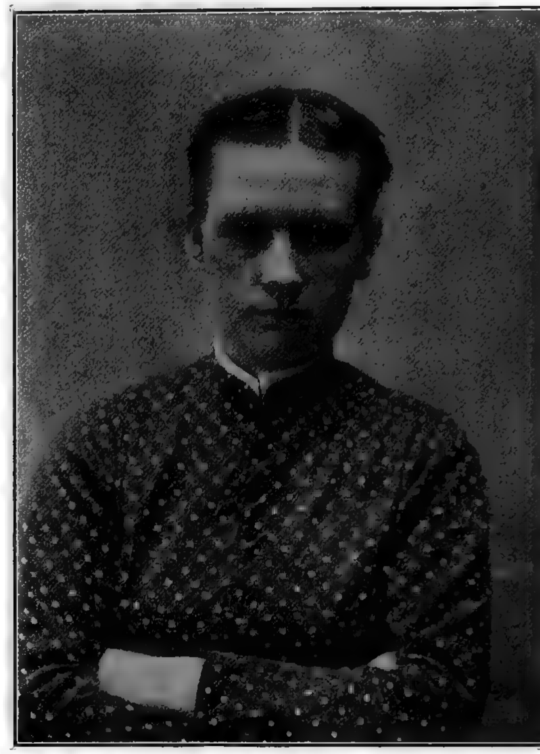

FIG. 2823.—Case X. Alternating Insanity. Depressed stage. Ocular divergence.

Figs. 2820 and 2821, Cases XXVII. and LV., illustrate the complete abandonment of the patient to the predominant emotion, the individual making no effort whatever to control the expression of the feelings. Case X., Figs. 2822 and 2823 respectively, show the transition of expression in the alternating phases of exhilaration and depression, both cases being subjects of manic-depressive insanity. In acute mania inhibition exercises no restraining influence whatever over the constant nerve-muscular activity which so transforms the physiognomy. Case XLII., Fig. 2818, illustrates how completely has intelligent control over the features been swept away by the storm raging within the cerebral centres.

The faces of the chronic delusional insane show quite clearly the absence of healthy inhibition. Thus the sly, distrustful glance, the bitter, lowering look of hatred and enmity, the self-satisfied air of exaltation, or the dejected countenance of self-abasement, are expressions quite frequently noted among this class of insane, and are another evidence of the inability of the patient, through impaired inhibition, to control the outward manifestation of the inner feelings. These same feelings exist in health, oftentimes with great intensity, and yet how perfectly are they concealed! In this connection it is interesting to note that in the weaker mental conditions of childhood these same feelings and emotions are frequently and as clearly represented in changes of facial expression as are the corresponding emotional states in the faces of the adult insane. The main difference lies in this fact, however, that in childhood inhibition through the will has not been developed, while among the adult insane it has been weakened by disease.

Case XII., Fig. 2824, quite plainly manifests in his countenance his all-absorbing egotism. In sitting for his portrait he chose his own position, arranging with great care his decorations, consisting of old buttons, bits of glass, brass wash-bowl chains, etc., which, as he imagined, possessed great value. The violin, which he made himself out of limited materials, and with an old knife and awl, he was anxious to display as a Cremona instrument of rare worth. The inconsistency of his real position (that of confinement for life in an asylum), the utter worthlessness of his jewelry and improvised insignia do not in the least lead to the inhibition of the expressions of morbid vanity and self-importance which pervade his countenance. Indeed, in nearly all forms of acute or chronic insanity characterized by active persistent ideas there will be noticed in the facial expression a complete abandonment to the prevailing morbid emotions, with scarcely any attempt at inhibition.

II. The second manner in which the physical expression of health is modified by insanity is through *excessive, deficient, or automatic nerve-muscular activity of an involuntary character, dependent upon morbid irritation or degeneration of the cerebral cell structure.*

It may be stated that all those movements which are caused by irregular cell activity of the cerebral centres

have one characteristic distinguishing them from the ordinary changes of facial expression: they are entirely meaningless, subserve no purpose, and do not conform to any of the well-known expressions of the emotions, as grief, joy, etc. In health the expression of these emotions is always recognized by certain well-known muscular contractions which observation has taught us are characteristic of corresponding mental states. We know, for instance, that laughter will be manifested by contraction of the *corrugators*, of the *malaris*, and of the great *zygomatic;* in grief we know that the eyeballs will be rolled a little upward and inward, and that the contraction of the central fibres of the *frontalis* acting upon the *corrugators* will produce a peculiar and very characteristic wrinkling of the forehead above and between the eyes, and that the *depressores anguli oris* will draw down the corners of the mouth. These muscular contractions follow in a certain definite manner their causative mental states. So regularly and constantly do they succeed their antecedent mental conditions that, given the state of mind, the resulting movements of expression can be foretold even before their appearance. Hence the expressions of the emotions can be easily separated into groups: thus we have the expression of joy, grief, disgust, and all the others.

On the other hand, the movements under discussion are not regular, do not indicate any particular state of mind, but represent rather that irregular and interrupted action of the brain cells which often takes place in acute insanity, and is of very frequent occurrence in the degenerative brain conditions of chronic alienation.

To avoid confusion we may study this phase of the physical expression of the insane under three heads:

I. As representing states of excessive nerve-muscular activity due to central irritation.

II. As representing states of deficient nerve-muscular activity due to central degeneration.

III. As representing states of automatic cell activity in the cerebrum occurring not infrequently in acute insanity, and quite constantly in the chronic form of the disease.

I. *Physical Expression of the Insane Caused by Excessive Nerve-muscular Activity.*—A certain constant and regular transmission of nerve force from the central cells to the muscular periphery is natural and in accordance with health. Indeed, a state of general good health demands this outward relief for the potential energy constantly accumulating within the brain cells. Thus the excessive muscular activity of all young and growing animals, the playfulness of young dogs and kittens, the pranks and follies of boyhood, are oftentimes merely the expression of this great natural law. In adult life the potential energy of cerebral cells is manifested in more practical and useful ways, but still in the most tangible results of a successful business, mechanical, or professional life we recognize the outward manifestation of the potential energy which has been stored up within the brain cells until the proper stimulation called forth its discharge.

In diseased conditions of the brain, however, the pathological irritation of these delicate nerve centres may be so great as to overcome any acquired inhibitory resistance, and thus liberate an excess of nerve force which will seek an outlet in the usual way by passing along the efferent motor tracts to the muscles, and there appearing as muscular movement. Thus it is that in the functional or organic brain disturbances of insanity, abnormal motor activities are a frequent accompaniment of disturbed states of mind.

Pathological motor activity is, as we have seen, spasmodic, irregular, and purposeless. The most striking illustration of this fact is afforded by cases of chorea and epilepsy. There seem to be good reasons for supposing that in these diseases the brain cells are in an unstable condition, owing to hereditary, traumatic, or nutritive disturbances, and that, as Gowers says, the discharge of these same cells "may depend on the production of force within being increased in excess of the resistance, or on the resistance being duly lessened" ("Epilepsy and other Chronic Convulsive Diseases," p. 213).

In the active stages of mania and melancholia, in the acute excitement which sometimes occurs in paresis and other organic diseases of the brain, this same discharge of nerve force takes place. The unceasing jactitation of acute mania, the restlessness of melancholia, are familiar illustrations. Such patients are apt to be in a state of constant muscular activity, pacing the floor, tearing their clothing, and destroying whatever comes in their way.

These irregular and motiveless movements of the insane are earliest manifested in the facial muscles. The extreme sensitiveness of this region to cerebral conditions, and the weaker inhibitory control which the brain possesses over these delicately poised muscles, are reasons why the face so often presents the first physical manifestations of the advancing mental disease. Very frequently the muscular disturbance does not extend beyond the face; but it is quite rare that this region does not show some evidence of the morbid irritation of the brain cells. When the face alone is disturbed in this way, the resulting expression is quite peculiar, and resembles those meaningless contractions that are produced when a mild galvanic current is passed through these muscles. The muscles are gently but continuously contracted, particularly those about the forehead, at the root of the nose, and about the mouth, giving to the patient a peculiar kind of *troubled* or *anxious* expression. It is often noticed by the friends at a very early stage of the disease, and they will tell you that the patient does not look natural, that his countenance has a strained, intense look, quite different from his normal expression, but still very difficult to describe.

In Case XLII. (Fig. 2818), the patient was entirely incoherent, and in a state of constant muscular agitation.

FIG. 2824.—Case XII. Paranoia. Morbid egotism and fondness for display. (From photograph taken by author.)

He was destructive, and almost too confused to eat his meals, so that frequent feeding with the nasal tube became necessary. The staring eyes, wrinkled forehead, dry, dishevelled hair, and torn coat are in striking con-

trast with Fig. 2819, in which the hair has assumed its natural condition, the face is smooth, and the eyes are calm and quiet.

In cases of melancholia with motor disturbance we see the effects of central irritation reflected in muscular agitation. Sometimes the patient will pace the floor wringing the hands, groaning and moaning, or the excitement will become so intense as to lead to an impulse to tear or destroy whatever comes within reach.

In many cases of chronic insanity almost constant tooth-grinding is a noticeable feature, and another illustration of morbid transmission of nerve force from the central cells to the muscular periphery. Tooth-grinding is not uncommon in nervous children, and is of very frequent occurrence in the insanity proceeding from structural brain disease. It is noticed oftener in connection with paresis than with any other disease. In passing through wards for demented patients it is a familiar sound, and sometimes is made with such force that it can be heard at a distance of thirty or forty feet. Warner thus alludes to this symptom: "Tooth-grinding is produced by the action of the deeply situated pterygoid muscles; champing of the jaws is produced by the masseter and temporal muscles; all these muscles are supplied by the fifth nerve, and it is to their condition that we must look for information as to the condition of the central origin of the nerve." By means of the Gasserian ganglion and small nerve filaments branching from it, the fifth nerve is brought into intimate connection with the dura mater and adjacent membranes. In chronic insanity associated with dementia these membranes are nearly always found to be in a pathological condition. It is quite natural, therefore, that morbid sensations should be transmitted from these diseased membranes, through the sensory branches of this portion of the fifth nerve, back to its origin in the pons Varolii and medulla, and thence be reflected outward along its motor tract to the pterygoid and masseter muscles.

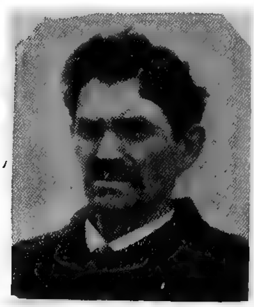

FIG. 2825. — Case XXXIX. Acute Mania. As he appeared on arrival at asylum from prison. Morbid innervation of facial muscles. (From photograph taken by author.)

In many cases of maniacal excitement attention has been called to the dry, rough, and almost bristling condition of the hair. In those patients who have recovered from mania the hair resumes its normal condition, is softer, and more easily kept in place. Illustrations of this are seen in Cases XXXIX. (Figs. 2825 and 2826) and XLII. (Figs. 2818 and 2819). In chronic or in recurrent mania the dry and bristling state of the hair is of common occurrence. One case under the writer's observation, that of a woman, was characterized by exacerbations of excitement, and at these times her hair was exceedingly dry and stood out in a striking way all about her head and face. In two cases the hair was naturally curly, but, as one result of the active mental excitement, there seemed to be imparted to it a stiffness quite different from that produced by the curliness; each individual hair, during the period of excitement, appeared to have a special prominence of its own.

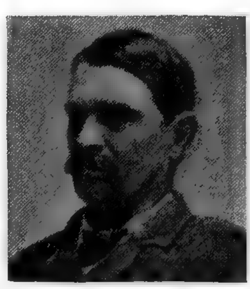

FIG. 2826. — Case XXXIX. Taken at time of discharge and recovery. Disappearance of morbid innervation, improved nutrition. (From photograph taken by author.)

This singular condition of the hair, in states of active mental excitement, has been alluded to by Darwin in his "Expression of the Emotions in Man and Animals." His explanation, which is undoubtedly correct, affords another illustration of excessive nerve-muscular activity following cerebral cell irritation. Every hair sac is provided with delicate unstriped muscular fibres—*arrectores pili*. These minute involuntary muscles are exceedingly liable to contract under the influence of strong emotions, such as fear and anger, as well as from the effects of cold. The contraction of these muscles causes a more or less complete erection of the hair shaft. Darwin concludes that "the erection of the dermal appendages is a reflex action, independent of the will; and this action must be looked at, when occurring under the influence of anger or fear, not as a power acquired for the sake of some advantage, but as an incidental result, at least to a large extent, of the sensorium being affected" (*op. cit.*, p. 102).

In the active mental excitement of mania, acute or chronic, persistent irritation of the cerebral cell structure leads to the transmission of nerve force along this channel to the *arrectores pili*—all the more readily because the natural emotions of fear and anger have made this a customary route. Hence in those forms of insanity which are accompanied by excessive nerve-muscular activity this erection of the hair is an almost inevitable result. This condition of the hair is seen only in those forms of mental disease which are characterized by active excitement or marked emotional disturbance. The bristling and erection is intensified by the dryness and roughness of the hair due to the impaired action of the subcutaneous glands. Darwin also informs us "that with man the hairs on the front of the head which slope forward, and those on the back of the head which slope backward, are raised in opposite directions by the contraction of the *occipito-frontalis* or scalp muscle" (*ibid.*, p. 297). This muscle is, as we have seen, often kept in a state of unnatural tension in conditions of pathological cerebral excitement, and hence its action would assist the *arrectores pili* in maintaining an erect and bristling state of the hair.

II. *Physical Expression of the Insane Caused by Deficient Nerve-muscular Activity due to Central Degeneration.*—Deficient nerve-muscular activity plays a prominent part in the etiology of the physical expression of insanity. A recognition of its existence in any case frequently enables the physician to make a correct diagnosis and prognosis of the mental disease affecting the patient. In nearly all forms of chronic insanity accompanied by mental enfeeblement, deficient nerve-muscular activity corresponds to the degree of mental impairment.

Whatever the pathological alterations in the brain cells may be, varying degrees of motor impairment constitute one very constant result in all cases of chronic insanity attended with mental weakness. We have already noticed how excessive nerve-muscular activity characterizes nearly all attacks of acute mania, as well as the excited stage of paresis, and the temporary exacerbations of excitement occurring in dementia. In these cases the nerve force is discharged in excess of the power of resistance, either because the inhibitory power itself is diminished, or because there is an excess of nerve force generated within the nerve centres. On the other hand, in cases of persistent and long-continued acute insanity, as well as in chronic insanity associated with the varying degrees of dementia above mentioned, deficient nerve-muscular activity is a prominent symptom. And the inference seems a legitimate one, that this deficient nerve-muscular activity represents or corresponds to certain degenerative processes occurring within the brain cells. This deficient nerve-muscular activity varies from the slightest motor impairment in a few of the delicate facial muscular strands to an extreme degree of general muscular paresis.

This deficient nerve-muscular activity represents imperfect or weakened innervation on the part of the central organ—the brain. All nerve tissue is endowed with one peculiar property, that of *sensibility*. By means of it, "the nerve cells feel excitation from without, and react in consequence, by virtue of the excitement of their natural affinities" (Luys, "The Brain and its Functions," p. 81). Impaired sensibility of the nerve cells is a fre-

quent result of protracted attacks of acute insanity, and a constant accompaniment of the various forms of dementia. And in such cases there is imperfect reaction to the various sensory stimulations which, in health, are being constantly transmitted from the periphery to the higher nerve centres of the brain. Dementia is characterized by imperfect responsiveness to external impres-

Fig. 2827.—Case LI. Chronic Dementia. Showing peculiar and uncomfortable attitude assumed by demented person as a result of morbid and persistant nerve-muscular activity. (From photograph taken by author.)

sions. It is difficult to arouse and interest such patients. They care little for their surroundings; they eat and sleep, but their energy seems lost. They lie or stand around in a listless way, and oftentimes it is necessary to speak to them in a louder voice in order to attract their attention.

Impaired nervous sensibility is attended with imperfect motor reaction, probably for the reason that the afferent and efferent tracts do not transmit impulses to and from the brain as readily as in health, and also because the brain cells themselves are less sensitive. Those regions which in health are most responsive to this excitation are very apt to be the first to become affected in diseases of the central nervous system. For this reason the face, in the earliest stages of dementia, begins to show evidences of impaired innervation. The lines about the eyes, the forehead, and the mouth, which were formerly well defined and which represented the healthy muscular tonicity already referred to, begin to lose their precision and appear to be smoothed out. The peculiar pose of the features, due, as we have seen, to the continuous transmission of nervous force along the various efferent nerve tracts to the muscular periphery, and which gives what we call character to each individual countenance, seems to have lost its definiteness. As a result the face begins to lose its expression, and in the very earliest stages of the disease constitutes a painful symptom for the friends to behold, and leads the physician to make a grave diagnosis and prognosis.

This defective nerve-muscular activity, which is first manifested in the faces of demented patients, in time extends to the larger muscles of the extremities. Demented patients become clumsy, and, if good mechanics, gradually lose the muscular precision which formerly characterized their work. Quite frequently such individuals are obliged to give up a certain line of skilled labor in which they formerly excelled, and undertake a less exacting branch of the work, or renounce it entirely before it becomes fully apparent that their mental health is being seriously undermined. At a still later stage of the disease the muscles of locomotion become impaired, and the patient grows clumsy in gait.

In the wards for demented patients in a large asylum one is struck with the slow, lumbering gait of the patients, with their lifeless attitudes and the general absence of healthy muscular activity which is evident on every side. A party of demented persons is easily recognizable at a distance. Their muscles, like their clothing, seem to *hang*, and there is none of that elasticity of movement characteristic of health.

This progressive muscular failure is quite noticeable in the cases of terminal dementia, which constitute so large a proportion of the population of public hospitals for the insane. Oftentimes these patients are under observation for years. In the earlier stages of their asylum residence they are capable of performing much manual labor. Gradually, as their dementia advances, they become less capable of sustained work; they may grow fleshy, but their muscles become weaker and more unreliable; and finally they cease to be efficient workers, and spend their time in the ward or on the grounds, lying or lounging about in a listless way. In these cases there is a real

Fig. 2828.—Case LVIII. Chronic Dementia. Peculiar and uncomfortable attitude maintained daily for years. Automatic nerve-muscular activity. (From photograph taken by author.)

failure in nerve-muscular force, which is represented by an inability to enter into mechanical employment, as was formerly their wont.

In cases of structural brain disease the order in which failure of muscular innervation occurs is quite interesting. First the muscles about the mouth begin to show weakness; then those about the forehead and between the eyes; later, the articulation begins to fail and to grow

more thick and indistinct; and the muscles of deglutition respond so feebly to innervation that the act of swallowing is rendered clumsy and difficult, and the patient is in

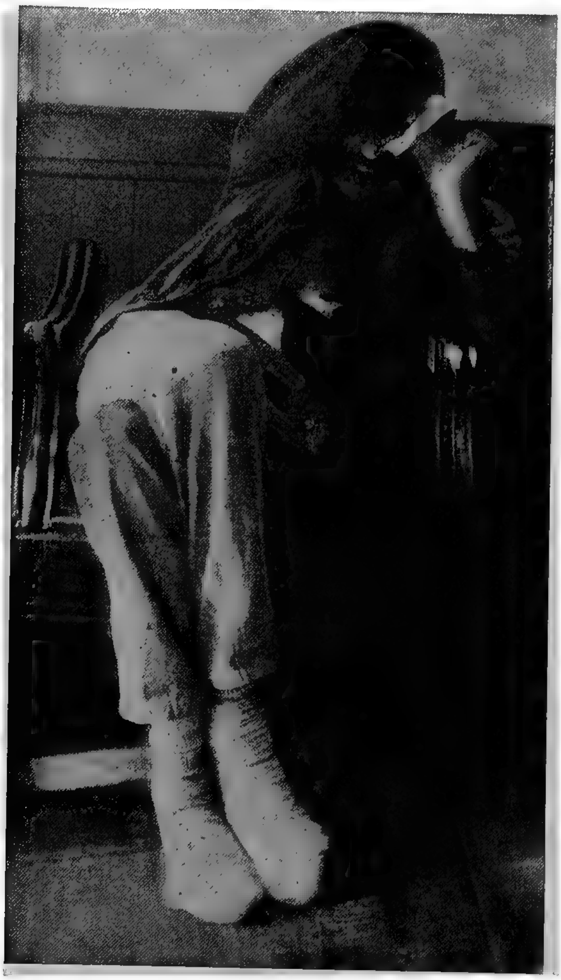

FIG. 2829.—Case LX. Chronic Dementia. Uncomfortable attitude maintained for a long period. Automatic nerve-muscular activity. (From photograph taken by author.)

danger of choking. Finally, the larger muscles of the extremities begin to weaken; the drooping head, shoulders, and arms, and the shuffling, clumsy gait indicate the steady progress of the brain disease.

Warner says: "In a strong and healthy man the head is held erect and symmetrical, unless some central condition or external agent changes the posture. In a strong man the centre of the forehead is in the mid-plane of the body, the antero-posterior and the transverse axes are horizontal, with both eyes on the same level; this is a normal position of quiescence" ("Physical Expression," International Scientific Series, p. 185).

In cases of progressive dementia, in the advancing stages of paresis, this failure of innervation is quite commonly seen in the drooping of the head.

In many cases the lower jaw drops on account of relaxation in those muscles which support it; this gives to the face an elongated expression, and quite frequently occasions the open, stupid-looking mouth so often seen in dementia.

Defective innervation, as we have seen, finally extends to all the muscles, and produces that peculiar drooping of the body, shoulders, arms, and even fingers, and that almost indescribable, but when once seen never-to-be-forgotten, clumsiness of gait and attitude so characteristic of demented patients.

III. *Physical Expression of the Insane, Caused by or Representing States of Automatic Cell Activity in the Cerebrum, Occurring not Infrequently in Acute Insanity, and Quite Constantly in the Chronic Forms of the Disease.*—A high volitional power distinguishes man from the lower animals. Even the most highly developed of these lower orders possess limited volitional powers. In them life is largely automatic, and distinct purposive direction of their actions is slight. Many of their acts that seem to display a high degree of intelligence and to suggest the power of voluntary selection prove, on close examination, to be merely the result of an unreasoning instinct which would not have admitted of any other course. In man, on the contrary, while his daily life is largely made up of various automatic activities, still the range of purposive selection is large, so that the "mechanism of thought and feeling" is made to serve the best interest of the individual through the guidance of the will.

In some way, at present obscurely understood, will power and functional activity of the cortex are mutually interdependent. Hence disturbance of these centres in insanity, caused by impaired nutrition, defective functional activity, or more gross structural lesions, weakens the will power of the individual. The functional activity of the cortical centres may be completely disarranged by insanity, and, as a result, the normal exercise of the will may be disturbed, if not entirely suspended. At the same time, however, the activities of the basal ganglia, no longer under the guiding and controlling influences of the cortical centres, continue automatically. As a result,

FIG. 2830.—Case LXV. Melancholia with Stupor. Showing persistent morbid attitude maintained for hours. (From photograph taken by author.)

purposeless thought and action of an automatic character are quite apt to follow those serious disturbances of the higher cerebral centres during attacks of severe acute and chronic insanity.

Automatic activity of the cerebral centres in health is subject to the direction of the will, and its results display

purpose. Automatic activity of these same centres in disease of the mind seems to be less under the guidance of the will, and the resulting action appears purposeless. In proportion as the will power is weakened by the brain disease do meaningless automatic activities of thought and action prevail.

In passing through the wards for the chronic and demented insane, one is struck with the evidences on every side of automatic activity. Here you will notice a man walking backward and forward in a mechanical way for hours together, until he has worn a beaten path in the floor; there will stand one who picks away at a certain place on his clothing for an indefinite period until he has worn the garment through to the skin. Quite frequently one will hear curious meaningless noises repeated in a mechanical way—singular repetitions of certain words or sentences wholly meaningless. It is not an uncommon thing for chronic patients to have some peculiar word or phrase, or even a single articulate sound, and to repeat it in an irrelevant way for years. In like manner you will meet with patients who make strange motions with the arms and hands, and take singular attitudes in a mechanical way. It is difficult to arouse the attention of such patients; their monotonous repetition of words and movements continues just the same, regardless of the presence of others, and with little reference to any attempts made for their diversion. All this variety of automatic action and speech would seem to indicate that the healthy functional activity of the higher cerebral centres has been disturbed and partially suspended, and that the lower centres are acting mechanically and without the normal volitional control.

Prolonged automatic activity in thought, speech, and action, among the insane, suggests a serious lesion in the higher brain. The more mechanical and purposeless the words and acts of the patient, the graver is the prognosis.

The nervous system manifests a striking tendency to mechanical repetition of any process once initiated within its centres. One epileptic attack is likely to be followed by another, and a number of seizures renders the prospect of still others quite certain, until in a short time the disease becomes firmly established. Both mania and melancholia manifest tendencies to repetitions of the attack, and each new attack renders the probability of another quite certain, until recurrency or permanent insanity is established.

In the advanced stages of fevers, such as typhoid and scarlatina, the higher functions of the mind are often suspended, either from exhaustion or because the cortical centres have been disturbed by the severity of the febrile action. In these grave physical conditions the automatic

FIG. 2831.—Case II. Dementia Præcox. Cataleptic stage. Muscular rigidity. Negativism.

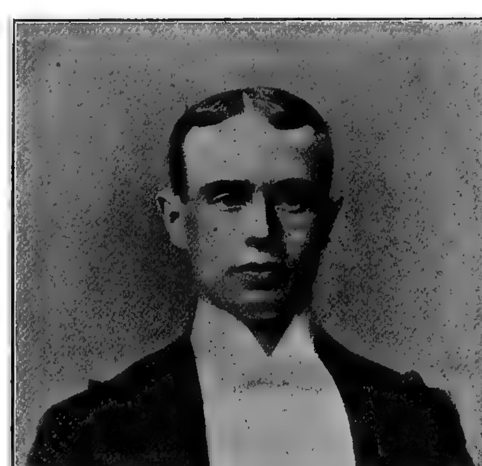

FIG. 2832.—Case II. Dementia Præcox. Remission.

and purposeless repetition of words and muscular movements becomes quite noticeable. Subsultus tendinum, carphologia, tiresome utterance of some particular sound or word, indicate that the higher cerebral functions have been suspended, and that the lower centres are acting at random and without the direction of the former. In this case the prognosis is grave because the vital forces themselves are waning and volitional activity is suspended through exhaustion of the cortical centres.

In chronic insanity the prognosis as to mental recovery of the patient may be equally grave, for the reason that healthy functional activity of the cortex has been permanently disturbed by the disease, which, though not necessarily fatal to life, is most assuredly so to mental restoration.

For the reasons just outlined the chronic insane are very likely to develop objectionable habits. The study of the physiological origin of many of the habits of this class of the insane would be most interesting and instructive.

FIG. 2833.—Case XIV. Dementia Præcox. Cataleptic state. Muscular rigidity and negativism.

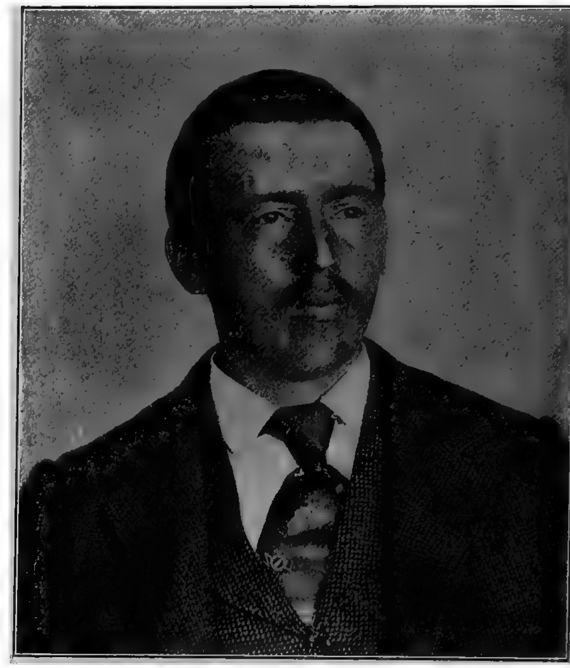

FIG. 2834.—Case XIV. Dementia Præcox. Remission.

FIG. 2835.—Case V. Dementia; remission following a confusional attack. Muscular tonicity restored. Ocular convergence.

FIG. 2836.—Case V. Dementia; an acute confusional attack. Entire absence of normal muscular tonicity; ocular divergence.

Two laws underlie every form of nervous activity, and furnish a physiological reason for the constant tendency toward automatic and habit action exhibited by the chronic insane in whom inhibitory impairment always

FIG. 2837.—Case VIII. Dementia Præcox. Stuporous state with muscular rigidity and negativism.

exists. 1. The discharge of the nerve centres occurs along those tracts which offer the least resistance. 2. The more frequently the discharge occurs along a given line, and the weaker the inhibitory resistance, the easier does a repetition of the discharge become, and the more certain its permanent automatic establishment.

If, for any reason, in those conditions of mental disease which are characterized by a weakening of the will power, one especial route is established either by reason of delusion or by mere fortuitous circumstance, the probability is that this particular route will continue to be the one most frequently traversed by nervous force in its passage from the brain to the periphery. A delusion, an hallucination of sight or hearing, some peculiar condition in the patient's environment may have first initiated certain actions which, by being unresisted, and hence repeated, lead to the establishment of a habit. Probably in some such simple and purely fortuitous way are developed the pulling out of the hair, tearing the clothing, walking in a beaten path, making singular motions or uttering meaningless sounds—in fact any of the countless strange habits of the insane. It matters little whether the performance of these habits is painful or disagreeable, no other alternative seems open to the patient when, through weakness of will and intelligence, the morbid route has once been established. Some morbid sensation in the scalp or chin to act as an excitor, or merely the absence of anything of an intelligent character to engage the attention, may lead to the plucking out of the hair or beard, which impulse, meeting with no resistance, soon develops into a persistent habit. A delusion about the bed may lead the patient into the habit of standing up all night, and if not interrupted, nothing short of restraint will prevent exhaustion, so persistent will the impulse become to remain on the feet.

The importance of the early breaking up of bad habits among the insane will be readily understood. Fortunately the same tendency to automaticity of action may be utilized in a good as well as a bad direction. By careful supervision we may succeed in breaking up many useless and vicious habits by supplying some simple mechanical occupation for the hands, thereby utilizing the automatic nerve activity characteristic of the disease. And in doing this we may even seem to retard mental deterioration. Judiciously selected, mechanical employment among the insane has become therefore a valuable means of treatment.

It is quite obvious that photographic illustration of the entire subject of automatic nerve activity is impossible, and yet enough in this direction may be shown to demonstrate the important part played by morbid automatic cell activity in the physical expression of chronic insanity, and, to a certain extent, in some forms of acute alienation. It is evident that illustration of this part of the subject must be limited to postures. The significance of postures in health has been referred to by Dr. Francis Warner in an article on "Muscular Movements in Man," in the April number, 1889, of the *Journal of Mental Science*. He says: "Postures depend upon the ratios of nerve-muscular action, and to some extent they indicate the present ratios of static efferent force proceeding from the centres concerned. Observations show that the postures, when not due to a present stimulus, or when

FIG. 2838.—Case IX. Dementia Præcox. Muscular rigidity, ocular divergence, negativism.

produced by a weak stimulus from without, such as a sound or sight, correspond to and are signs of the general condition of the central nerve system."

The postures maintained, oftentimes for long periods, by the insane possess a special interest because they are a pretty sure index of the morbid condition of the central organ of innervation.

Cases LI., LVIII., and LX. (Figs. 2827, 2828, and 2829) illustrate peculiar and somewhat painful attitudes which were taken by patients suffering from secondary or terminal dementia. And in Case LXV. (Fig. 2830) is seen a singular position maintained by a patient in a condition of stuporous melancholia. In these and similar cases the intensely interesting question is always suggested, How came such peculiar habits to be initiated? The wards for demented patients present numerous cases of this character which will afford material for physiological and psychological study. The careful investigation into the early development of mechanical movements, attitudes, and meaningless habits among this class of patients would amply repay the time and labor expended in this direction, and thro v some light on the processes of cerebration and their connection with muscular movements.

The singular postures shown in the photographs of Cases LI., LVIII., and LX. (Figs. 2827, 2828, and 2829) were gradually assumed by the patients while under the writer's care, and yet so very slowly were they initiated that they became fixed and habitual positions before any especial attention was called to the fact. In this way the real causes that led up to the final establishment of the habitual posture were lost sight of. From what was known of the patients, the impression would be readily formed that in Cases LVIII. and LX. delusions of suspicion or a dislike to seeing persons about led to a habit of hiding the face, as is often witnessed among bashful and diffident children. As these particular patients became more demented, a position which was at first assumed as the result of an active delusion finally developed into a permanent habit, simply because nervous force, flowing along this route from centre to periphery for so long a time in obedience to impulses derived from morbid ideas, and meeting with little inhibition, continued to take this route long after active thinking had ceased.

Another interesting fact concerning these strange attitudes assumed by these patients is, that they seem utterly oblivious to the discomfort and even the painfulness of these constrained positions. Cases LI. and LX. would maintain the posture for hours; and Case LVIII., from the hour of rising until bed-time, was continually in the attitude shown in the photograph. The muscles concerned in the maintenance of these postures were in a high state of tension, showing that a certain amount of "static efferent force" was being transmitted continuously from the centres within the sensorium to the periphery over these morbidly pre-established routes. Nearly all the other healthy activities of mind seemed in these cases to have ceased with the exception of the mere processes of organic life, and the entire energy of the sensorium was expended in keeping up these automatic and useless positions. Any attempt to move the arms into a more easy position was met by firm resistance, which was not spasmodic but persistent in character. That these attitudes would be painful to a person in health, any one can demonstrate by attempting to maintain similar positions for even a few minutes at a time.

The cataleptic conditions that are such a constant accompaniment of the stuporous state of *dementia præcox* afford a good illustration of automatic cerebral cell activity. During this phase of the disease the muscles become rigid and contracted and cannot be moved without quite a degree of force. The *negativism* so characteristic of the mental operations extends to all the muscles. During the remission all this muscular tension ceases and the patient returns to his normal physical expression. Cases II., XIV., VIII., and IX. illustrate the automatism and rigidity accompanying this disease at its height, with the return to a natural state upon the subsidence of the central disturbance.

Finally, disturbances of motility are quite frequently reflected in the varying expressions of the eyes. In mania there is increased brilliancy of the eye and marked mobility of that organ. In melancholia there is ocular parallelism or divergence, in which condition the person seems to take no interest in his environment. In dementia and in the stuporous states of melancholia and *dementia præcox* there is a dull lustreless condition of the eye. Oftentimes the eyes have a staring look, and in many forms of insanity all attempts at diversion are futile, the patient continuing to manifest that painfully stony and glaring aspect which shows how intense is the mental absorption. Indeed, one of the first symptoms of insanity observed by the friends of the patient is this peculiar expression due to ocular parallelism. They often refer to a certain strange, unnatural, or wild appearance about the eyes which is undoubtedly brought about by the divergence due to almost constant morbid preoccupation of the attention. In health the eyes are in a state of gentle convergence—such a condition being necessary to binocular vision. The least withdrawal of the attention from any object in the immediate environment is at once followed by a partial relaxation of the recti muscles, and as a result the eyes slightly depart from their condition of convergence and appear to be directed forward in nearly parallel or slightly divergent lines. Such divergence is usually quite temporary, lasting only during the mental preoccupation. So too in mental disease the eyes, either from morbid preoccupation or from deficient ideation due to structural or functional disturbance of the brain, are reduced to a condition of quite continuous parallelism, giving that appearance of abstraction so characteristic of the insane. Illustrations occur in Case XXXIII., Figs. 2816 and 2817; Case X., Fig. 2822.

Enough has been said to indicate the prominent part played by physical expression in the symptomatology of insanity. The intimate association of muscular movements and morbid states of mind serves to demonstrate the close functional relationship of the various brain areas and their mutual interdependence.

Charles P. Bancroft.

VI. INSANITY: GENERAL DIAGNOSIS.—Border Lines of Insanity.—Insanity is made manifest in the individual by a departure from the normal in his conduct and conversation, without regard to a consonant change in the conditions of his environment. The recognition of the outbreak of mental disturbance is therefore not difficult; but when we have to go further, determine the nature of the aberration, its probable cause, and above all its probable duration and the prospect for recovery, we must have something else to guide us than the manifestation itself.

In considering the subject of the general diagnosis of insanity, we are confronted by a serious difficulty which results from the involvement of the subject, on account of the various conceptions which are current concerning what is constituted in its manifestations. That is, what is insanity and what do we mean by the term? We cannot explain its manifestations in the terminology of metaphysics, nor describe them as the result of certain morphologic changes in the cells of the brain cortex. For we must recognize that while it is true that certain morbid histologic changes are always present in the brain in those who die insane, these same changes are also found in the brains of those who are not insane, especially in the brain cortex in old people and those who have been the victims of toxæmia affecting the general nervous system. Besides, there is no constancy in the relation between the degree of morphologic change in the neuron and its extent, nor any correlation of the nature of the mental disturbance and its kind. What, then, is insanity? In seeking for a standard by which to judge between sanity and insanity, we are forced to create an arbitrary and, in a measure, ideal individual, with whom we may compare all men and judge of the existence and degree of insanity in the given case, by the departure of the individual from this standard. This ideal individual can be defined most simply and completely by Herbert Spencer's abbreviated definition of life, as one who can perfectly "adapt internal to external relations." Any deviation from this standard is literally insanity, although it is not so recognized until the deviation becomes so marked as to be conspicuous, on account of so faulty an adaptation of internal relations as materially to interfere

with the welfare of the individual and his relations to those about him. The various forms which this deviation may assume will be determined by the degree of imperfection in the nervous organization of the individual and the influence of environment. That is, if the relative imperfection of structure exists only in a certain definite direction, the faulty adaptation will be in that direction; and if the environment of the individual be such as to increase this faulty adaptation it will be to that extent exaggerated. The definition of heredity with relation to insanity is as much involved by difference of opinion as to its significance, as is the definition of insanity. The usual conception of the relation is, that the insanity is not the result of hereditary conditions unless the immediate progenitors or collateral relatives of the individual have been insane. The equation is not so simple, however. For the parents of the insane individual may be sound mentally, but the victims of some constitutional disease which will affect adversely the development of the child. Without doubt we can definitely assert that there is a limitation of the potentiality of the different parts of the organism in each individual, and that this limitation applies to the capacity of the organism as a whole to meet the conditions in its environment.

Also, this potentiality is seldom equal in all parts of the organism. So that, while the individual is capable of meeting the conditions present in the environment in which he was born and grew up, he would not be equally capable of meeting the conditions of an environment differing materially from his own. Now if this is true of the normal individual, how much more is it true of the individual who for any reason is defective and whose capacity is limited? This assumption is illustrated by the facts of senility and in the irregular manner in which its processes are usually manifested, as well as in its premature appearance. It follows then that this limitation of potentiality which may manifest itself in instability, incapacity, or defect in any part of the organism must have its origin in inherent want of capacity, which handicaps the individual from the beginning of his existence. Following the well-known law of degenerative processes, those parts of the organism which are last in the order of development and most complicated in their structure will be the first to be limited in their capacity and show the evidence of lessened potentiality. For this reason, no matter what the nature of the incapacity in the parents, in the offspring the potentiality of the nervous system is, other things being equal, most likely to be limited. The recognition of hereditary influence has therefore to take into consideration the transmutation of form in the transmission from one generation to the other of constitutional or diathetic conditions affecting the parents, and even the effect of temporary causes affecting the vitality of the parents at the time of conception. That is, any condition which produces somatic degenerative changes in the organism of the parent may be manifested by brain degeneration and mental aberration in the offspring. Thus the children of the syphilitic, tuberculous, or gouty may be and commonly are the victims of degenerative disease of the nervous system and insanity. So that, while as generally understood the children of the victims of these diathetic conditions who become insane do not directly inherit the tendency, practically they do by the transmutation of the diathetic conditions between parent and child.

When we take into consideration that insanity is the manifestation of alteration, not destruction, of function, we can appreciate that the activities involved are the same in amount and kind in both normal and abnormal mental activity. In the one case they represent a response to external stimuli, the effect of which is habitual, while in the other they are excited by centrifugally generated stimuli, more or less out of accord with external relations. There is no abstract difference between the conduct of the sane and the insane. The difference lies in the nature of the experience which gives rise to the conduct, and the loss of control of the activities which are manifested in conduct. The function of the activities of the organism is to conserve the welfare of the individual by adaptation to his environment. Because the result is disastrous to the individual who is insane and it interferes with his relations to those about him does not alter this fact, but shows only that the manifestation is aberrent with failure in adaptation as the result. This failure in its turn brings exhaustion, with abeyance or destruction of function. Now when we consider further that the conditions under which society exists and men live are comparatively uniform in a given community, it follows as a corollary that capacity for continued adaptation depends upon integrity of structure and functional potentiality. So far the analogy between the different portions of the organism and the laws which govern their functional activity obtains, but when we come to consider that the nervous system is concerned in the controlling of the activities of the rest of the organism, and the direction of the sum of these activities in the maintenance of the individual, the analogy no longer obtains. And when we further consider that the most highly developed portion of the nervous system has another function in the cognition of the ever-varying conditions in the environment of the individual, and their relation so as to direct the somatic activities involved best to meet the changes in the environment, the wide difference in and the great complexity of the processes becomes apparent. Whether mental activity is represented in the most unstable cells of the cortex independently or is represented synchronously with motor generative activity, and is the reflex of the association of all somatic activities, has not been demonstrated and may not be capable of demonstration, but it would seem to be the most reasonable assumption from the data we have. The pathologic history of insanity is known to be vague and indefinite, and from the standpoint of histology furnishes very little information to the student in search of specific morbid changes which will explain the clinical manifestations of aberrant cerebral functioning. This apparent absence of definite anatomical change is to be explained by the conditions which give rise to insanity—namely, the precedence of physical disease, shock, overwork, mental strain, infection, or auto-intoxication from some source. Consequently the insanity cannot be said to be dependent upon the changes found to be present in the neuron, but rather the histologic change and the insanity follow the conditions generated by antecedent somatic changes, to which they are consecutive. However, as the degenerative process with disintegration goes on, there does follow mental reduction, and this is always in proportion to the destructive change in the neuron. All sensory and motor manifestations, physiologically considered, represent different modes of motion resulting from activity in the nerve cell, and this activity is constituted in the chemical changes which take place in the unstable complex organic material of which the nerve cell is composed. The tendency in the potential nerve cell is to manifest its activities along definite lines, the degree and nature of the activity being dependent upon the character and force of the stimulus.

Biologic chemistry teaches us that all organic compounds are unstable, and that in the functional cells of the animal organism the relative instability is much greater than in all others. Also that this instability increases with the activity with which the function is performed. Consequently we would expect to find, as we do, that the structure of the functional nerve cell is the most unstable of these compounds. It is then the corollary of this statement that the activity of the nerve cell depends upon its sensitiveness to stimuli resulting from this instability, and that its capacity for continued function depends upon its ever-recurring reconstitution. In an organism with nerve cells having a definite potentiality, this reconstitution would obviously continue as long as the organism existed. But if, through some incompleteness or irregularity in the development of the cell, due to hereditary or acquired causes of imperfection, the reconstitution is not complete, the result will be a greater instability of the compounded elements of the cell, making it more easily

broken up, or, in physiological terms, increasing its irritability. This increased rapidity of decomposition and reconstitution implies a greater amount of waste and need for increased quantities of nutriment, consequently an increase of all of the other organic activities implied. Now if from any cause the general organism is incapacitated for supplying the increased quantity of nutriment, there must necessarily be an imperfect reconstitution of the nerve cell and a consequent reduction in type with restriction of activity, which, if continuous, finally brings about dissolution and destruction of function.

It may be assumed that the new-born child has a brain mass with a definite potentiality and endowed with certain hereditary tendencies; that the mental life of the adult individual is the sum of the products resulting from the influence of experience upon this potentiality and of environment upon the inherited tendencies. In the developed individual the general nervous system has a dual function—the direction of the somatic and the correlation and co-ordination of the mental activities. Just as the functioning of the brain and general nervous system in the direction of somatic life is a manifestation of motion, so probably is the functioning of that part of the brain which presides over mental activity, their interdependence and dependence on the other functions which they direct and control being analogous to that existing among the vegetative organs. Again, this definite mode of reception, comparison, and relation of external and internal impressions, which we call mental activity, involves special functioning, with resulting tissue change, which increases and decreases in a direct ratio with its activity. That this function of the brain is a comparatively separate one, carried on in a great measure independently of the general manifestations of nervous energy, is shown by its absence in the new-born child and in the fact that in the adult the gravest disturbance of this function may occur, or even its entire extinction, without materially interfering with the vegetative existence of the individual. There is an interdependence, however, which is essential to the proper performance of both functions. The impressions—the relation and storing of which, with the concomitant direction of vital energy, which forms the material with which the psychic function has to deal —are brought to it through the channels of the general nervous system for elaboration into thought and ideas, and it follows that the proper performance of the functions of the brain depends upon the relative perfection of its parts and their adaptability to the demands to be made upon them. Furthermore, when we consider that under the influence of the general disturbance present in insanity, with the intensification or abeyance of the organic activities associated with the mental disturbance, it will be readily understood how not only the nutritive and eliminative changes in the brain will be interfered with, but the functioning of the rest of the organism as well, so that the work done by each organ will be incomplete and aberrant in form. Thus the general and local conditions, acting and reacting upon one another, prevent the reestablishment of normal functional activity in the brain, and bring about the persistence of those conditions, primarily dependent upon some temporarily acting cause, which result in the upsetting of an unstable nervous organization.

We have then to consider hereditary or acquired imperfections in the structure or functional potentiality of the nervous system, the influence of the general changes in the organism, the reaction of the perverted functioning of the brain on the general organism, and the implication of certain portions of the general nervous system by destructive changes. Although not yet demonstrable, it is highly probable that there can be chemical imperfection of structure, even where there is no morphologic change apparent, and that this imperfection or incompleteness may operate to produce an abnormal tendency to decomposition following the application of a slight incident force, or, expressing the same conclusion in physiological terms, a tendency to react excessively to slight stimuli. Applying this definition to the nervous system, we see this tendency manifested in an exalted but indefinite and non-persistent mental and motor activity, examples of which are a matter of daily observation among so-called nervous people. Again, hereditary or acquired conditions may determine a defect or impeding of development, which will show itself as a tendency in an unstable nervous organization to break down in certain directions, whereas integrity of structure and normal functioning may persist throughout in other directions.

We have next to consider that through disease or even disturbance of the circulation in the conducting tracts of the nervous system, either in the path of sensory or motor impulses, or in some of the subsidiary centres, perverted impressions may be carried to the cortex. Such aberrations of function occur constantly in the presence of fatigue, mental strain, or bodily disease among those who are not insane. How easy it is to account for their exaggeration and persistence if they take place in a nervous system which is primarily defective. Lastly, we have to consider the influence which impaired nutrition, occurring as the result of exhaustion of vitality, either through overwork or bodily disease, may in the presence of the factors just described have in determining an outbreak of insanity. Here again a little reflection will show that the most profound exhaustion from overwork or bodily disease may occur without producing insanity in the ordinary individual. What, then, is the necessary factor? Obviously an unstable nervous system or one with a limited potentiality. The unstable nervous system will be easily upset, and as a result its functions will be manifested aberrantly or in excess, as we see in hysteria, neurasthenia, depression with or without emotional disturbance, maniacal excitement, or delirium. The extent of this disturbance of equilibrium will always be in proportion to the degree of instability and the nature of the exciting cause. In those cases in which the strain upon the vitality of the individual has been prolonged or excessive, there may follow stupor or coma, as seen in typhoid conditions, after surgical procedure, during the puerperium, in acute alcoholism, and in some forms of chronic intoxication. In the nervous system of limited potentiality the tendency will be, under the conditions described, toward the establishment of the process of degeneration, which will, in its turn, vary in degree and extent with the amount of limitation and the nature of the strain. The unstable brain of necessity also has a limited potentiality, so that even after the mildest outbreaks of mental disturbance there is some mental reduction which is permanent. Again the progress of degeneration may be so slow or retarded by changes in the environment of the individual that years may pass with but slight alterations in character being manifest—usually in the form of lessened self-control, increased self-consciousness, suspicion, or a tendency toward confusion in or after unusual or extended mental effort. For obvious reasons physical disease, either acute or as manifested in the changes accompanying chronic degenerative processes in the vegetative organs, would also make manifest the disturbance of an unstable nervous system or the presence of degenerative change resulting from limited potentiality. These conditions constitute what are ordinarily called the border-land manifestations of insanity, because the changes are as a rule slight, take place slowly, and although there may be explosive outbreaks accompanying them, they are short-lived and do not suggest their real origin. The family and friends of the patient having become accustomed to the changes in his character, the presence of actual mental aberration is not suspected nor recognized until some marked manifestation of untoward conduct makes the true condition apparent. In these border-land states the patient is commonly fully alive to his condition, even if he does not appreciate its significance. The difficulty in making a correct diagnosis does not result from failure to recognize these vague and ephemeral manifestations, but rather from the inability to appreciate their extent, because in the one case they may go no further than the temporary loss of control, confusion, or delirium, while in another, even where the con-

ditions in the environment of the patient may apparently be favorable, the outbreak will be prolonged indefinitely and the mental reduction may be permanent. To this class belong those individuals who develop the different phobias or who have persistent impulses toward foolish, vulgar, or criminal conduct, as illustrated by involuntary mimicry, coprolalia, kleptomania, and sexual inversion or perversion. The only guide we have for determining whether or not the mental aberration will be temporary or permanent is the history of the individual as to the extent to which it reveals instability or defect. As a rule, the children of the insane and neurotic are unstable, while the children of those suffering from diathetic conditions are defective. Therefore in the former the presumption is in the direction of the mental disturbance being temporary, although liable to recur. In the defective, however, the probability of the eccentricity and erratic conduct being the beginning of a permanent degenerative process is very great, especially so if physical exploration shows the presence of chronic degenerative change in the vegetative organs.

Examination of Patients.—In conducting the examination of a person supposed to be insane, it is important to eliminate the personal equation in yourself, and to be able to recognize its influence upon those who have the patient in charge. Next come the recognition and appreciation of the natural capacity of the individual, the limitation of his mental horizon, and his attitude toward his environment. You would not expect the same clearness of definition in the conceptions of an illiterate man existing in primitive surroundings as you would in those of a cultured man with a wide mental horizon. As a rule, the insane present some or all of the stigmata of degeneracy, both physical and mental; the physical stigmata being more common in the defective, the mental in the unstable. They represent different degrees of defect in the development of the individual, and in the nervous system limitations of potentiality. That is, the individual with these evidences of degeneracy present, and the limitations which they imply, might under favorable conditions live his life through without mental disturbance, but does break down under the stress and strain of social and industrial competition, as the result of disease, shock, overwork, or excessive exposure; and this breakdown will be temporary or permanent according to the degree of defect in his nervous organization and the extent of the strain. Furthermore, none of the symptom groups on which classification has been predicated are distinct entities, but, on the contrary, all of the different manifestations of mental perversion may be, and often are, present in a single individual during the course of an outbreak of insanity, while mental reduction is common to them all. Syphilis, gout, rheumatism, alcoholism, phthisis, traumatism, etc., are not direct causes of definite forms of mental perversion, but rather, by their effect in interfering with nutrition and elimination, the means of exhausting the limited potentiality of the individual; and the mental perversion which follows may manifest itself in any form. For example, the syphilitic degenerate may, when insane, be either exalted or depressed, excited or agitated, the victim of hallucination, well-defined delusion, or mental reduction may be profound from the beginning of the outbreak, and dementia supervene without any manifestation of active perversion; and so with other causes of somatic degeneration. Psychologically, analysis of the aberrations of mental processes shows that they are not of different kinds, but vary in degree. Hallucination of the special senses is either pleasurable or painful. The picture formed and the delusion which results has the same characteristics. That is, all insane people when exalted have agreeable conceptions, and when excited or depressed have persecutory or depreciatory ideas, their definition depending upon the mental capacity, extent, and variety of the life experiences of the individual. If you will go through a hospital ward, carefully observing each individual, you will find one patient sitting with rapt intent expression on his face; another with head turned to one side as if listening intently, the expression varying from complaisance or self-satisfaction to anxiety, dread, fear, or anger. Another will be standing, excitedly gesticulating and denouncing. Still another, sitting with bowed head, a sullen and gloomy expression on his face, suddenly straightens up and strikes the one nearest him, again lapsing into sullen gloom, or continuing the assault, and accompanying his blows with a tirade of denunciation or abuse. All this seems purposeless, but careful observation and questioning will disclose the fact that each of these individuals has heard or seen, and often both, voices and presences, agreeable or disagreeable, pleasing or threatening. Perversions of the olfactory, gustatory, tactual, and muscle senses may be and often are present as concomitants of the belief formed out of the primary illusion, resulting from the auditory or visual hallucination. Visceral consciousness is commonly a most potent factor in the development of the belief that poison is being administered, and the sinking sensation, characteristic of some forms of intestinal indigestion, a bruit of the abdominal aorta, and all sorts of gastric sensations, with the suffocative feelings attendant upon gastric distention, are perverted to signify the effect of poison, the administration of anæsthetics or narcotics, and electric influence; while among the lower types these sensations are significant of occult or demoniac influence.

All of us hear sounds, see sights, and perceive odors and tastes. We are subject to disagreeable tactual sensations and to visceral consciousness, but we correct our false impressions through the influence of environment on our consciousness. Why is it, then, that the insane man fails to correct his false impressions? Referring to what has been said about the morbid self-consciousness and limited self-control of the unstable and defective, we can easily see how, as the result of mental strain or physical exhaustion, the tendency to introspection would be exaggerated. If this persists, irritability shows itself, and suspicion follows. The actions of others, heretofore a matter of indifference, take on a new meaning and have especial significance. In the development of insanity, after the persistence of irritability and suspicion for a time, with the continually increasing tendency toward introspection, and the relation of external phenomena to self, dread is added, ordinary sights and sounds have a special purport, and are associated with experiences in the life of the individual which have been untoward or unfortunate. As a result of the constant suspicion and dread confusion supervenes, and the voices of those by whom the individual is surrounded are heard to utter threats and sneers, to make accusations, or suggest ulterior motives for ordinary actions; while to the sight, the conduct of friends or relatives assumes a corresponding significance. The individual becomes impervious to evidence or demonstration. The persistence of sounds and sights forms a picture of that which is dreaded and feared. Suspicion ends in the certainty of belief, the nature of the belief varying with changes in the environment, governed largely by the previous experiences of the individual, changing in form, but always having the same substantive basis, the definition of the belief varying with the amount of mental reduction. So that where this is slight the definition may be constant in form, as in the paranoiac, or in that analogous form of chronic delusional insanity so common after the climacteric in both sexes. On the other hand, the definition may vary from moment to moment, as in the rapidly changing phantasmagoria present in acute mania, or be only suggested, as in the vague uneasiness associated with acute depression.

Insanity, although never directly due to bodily disease, is often precipitated by it and is always accompanied by more or less disturbance of the bodily functions. Again, although the tendency toward insanity is in the majority of cases hereditary, actual insanity in the parents or near relatives is not the only hereditary condition operating to produce mental disturbance. Consumption, rheumatism, syphilis, alcoholism, or any constitutional imperfection in the parents is equally potent in bequeathing an unstable

nervous organization to the child, with the resulting tendency to break down mentally under the influence of bodily disease or mental strain. Conditions arising during the pregnancy and labor of the mother may influence the mental stability of the child, as well as the occurrence of infantile disease accompanied by prolonged high temperature, convulsions, or great exhaustion. Unfavorable conditions surrounding the advent of puberty, the progress of adolescence, and in women accidents or diseases connected with pregnancy and labor, the puerperium, and the period of lactation, or the advent of the climacteric are often exciting causes of insanity in those predisposed. In men, prolonged exposure, overwork, and insufficient food, syphilis, alcoholism, or severe acute disease accompanied by high temperature or exhausting discharge will operate to produce a similar result.

As insanity is manifested by the perversion of the normal activities of the individual, both bodily and mental, therefore the first thing to determine is the normal plane of his bodily and mental activity. To this end inquiry should be made into his habits and conduct before the outbreak of mental disturbance, especially as to the degree of intelligence and his moral qualifications, his resemblance to other members of the family, and wherein he differs from them. This information, together with the family history, will furnish a standard by which to judge how great a departure from the normal his present condition indicates. A careful study of the statements and beliefs of the patient should be made, his reasons for them, also the foundation for his beliefs and the motives for his conduct. These inquiries will determine the presence of perversion of the special senses, while the degree of intelligence the patient manifests in defending and explaining his conduct will indicate the presence and degree of mental reduction. In women it is important to know at what age they began to menstruate, and whether the function was established without systemic disturbance, the presence or absence of headache or pain, and whether the periods are too frequent or delayed. If she is a married woman, inquiry should be made as to her pregnancies, their number and frequency, the condition of the general health during the period of gestation, and whether there had been any alteration of character or habits; also as to the character of her labors, the history of the puerperium and period of lactation, and the degree of regularity in the performance of the menstrual function between her pregnancies. If she has never borne children, inquiry should be made as to the occurrence of miscarriage; or, if she is sterile, whether the sterility is dependent upon imperfect development, deformity in the sexual organs, or is the result of disease. These inquiries will show the relation, if any, between the mental disturbance and the condition of the reproductive organs, especially if menstrual disturbance or pelvic disease have been associated with the onset of the insanity. In both sexes the condition of digestion and the excretory functions should be investigated. Finally, the nature and kind of occupation to which the patient has been accustomed, whether it has been recently changed, made more laborious or confining, and especially if the change has been from an active outdoor life to a sedentary one. Nothing in relation with the functions, occupation, and surroundings of the patient will be unimportant.

Feigned Insanity.—To feign insanity is very easy and yet very difficult. The reason for this paradox is that the ordinary individual is almost certain to blunder, so that he will be recognized as a malingerer. However, the man of intelligence who is a good actor may after careful observation imitate the manifestations of insanity so closely as to defy detection at the time. Another paradox involved in this subject is that the insane may and do feign insanity. This feigning of insanity by the insane most frequently occurs in connection with the criminal acts of those who have been for some time on the borderland, and who have been able, until the outbreak which culminated in the untoward act, to control their conduct. Recognizing what must follow, they mimic the outward manifestations of active mental disturbance, in order to shield themselves from the consequences of their acts. Others exaggerate their condition to frighten those about them or to attain some object they have in view. The form and manner in which the feigning of insanity may be attempted will be determined by the character and experience of the malingerer. Naturally the man of education will be guided by the knowledge gained from reading and observation, while the illiterate individual will follow the suggestions of tradition and folk knowledge as to the supposed characteristics of insanity. Those who are unfamiliar with insanity do not recognize its manifestations unless they take some active form, such as violent excitement or bizarre conduct. They are loth to admit the fact of insanity if the individual answers ordinary questions intelligently and claims to be sane. So that the malingerer is naturally tempted to extravagance in the manifestations of the mental disturbance he is feigning, and he especially tries to indicate by his conduct and conversation the absence of intelligence. He may appear to be stupid, the victim of hallucination, incoherent, delirious, or maniacal, but all of these are as a rule exaggerated. The man who is really insane believes that he is not, and is constantly at pains to argue the matter. This is not true of the man who would feign insanity. The malingerer most frequently presents the phenomena of amnesia, especially if his conduct has been criminal, and along with these manifestations he will mimic the physical expression and personal indifference of dementia. The conduct of the really insane man is always out of consonance with his environment, and in those forms of mental disturbance which are usually feigned there is always considerable mental reduction which is persistent during the attack. Herein is the final test of insanity, for mental reduction cannot be successfully imitated all of the time nor for any length of time.

We have then to consider, in making a diagnosis of feigned insanity, the conduct of the individual, and, if it is manifested in criminal acts, its relation to his environment at the time, and consonance with his character and habits, which are usual and habitual; whether the amount of mental reduction present is in relation with the kind and degree of mental disturbance, and if the mental reduction is persistent. We have next to remember that the really insane man does not realize his condition, and his morbid self-consciousness leads him, if he is intelligent enough, persistently to assert and argue his belief in his sanity. Finally, the crux of the question is what is meant by the term. Legally a man might be considered to be feigning insanity when scientifically he is not, for it is doubtful if the effort to feign insanity is ever made by a perfectly sane man. There must be the morbid egotism of the neurotic to prompt the man to simulate a condition which the normal individual looks upon with dread and horror. *Harry A. Tomlinson.*

VII. INSANITY: GENERAL PROGNOSIS.—*Statistics.* Thurnam's frequently quoted paragraph giving his conclusions from a generalization of the histories of the patients at the York Retreat will best introduce this subject. They possess a certain value, as he was able to trace the after-history of every patient who had been at the retreat *in whom death occurred.* He wrote: "In round numbers of ten persons attacked by insanity five recover and five die sooner or later during the attacks. Of the five who recover not more than two remain well the rest of their lives. The other three sustain subsequent attacks during which at least two of them die."

These statistics barely approximate the truth, and are open to several objections, the chief of which is that they represent hospital cases only, which are most likely to be of the severe, difficult, and chronic variety. They cover therefore but part of the ground, and a vastly different idea of the prospect of cure would prevail if the undoubtedly large number of cases—chiefly melancholia—which recover without going to a hospital or even (as Blandford believes) to a doctor, could be included. At the same time these results are instructive and sufficiently

accurate to enable one to make a fair estimate of the termination of insanity in general. They show plainly that not a small proportion of patients have incurable forms of mental disease, characterized in the main by a succession of attacks which are followed by temporary returns to a degree of rationality sufficient to warrant the name of "recoveries."

Importance of the Form of Insanity.—If we analyze these cases we shall find two classes of patients, one in which the attacks occur very irregularly and are of a variety of forms—mania, melancholia, stupor, confusion, etc.—modified, it may be, by minor conditions, such as katatonia or catalepsy. Moreover, succeeding attacks are rarely of the same kind. In these patients the interval of so-called recovery is of the nature of a remission of varying length, and the mind, though sometimes clear and apparently sound, never again returns fully to its normal condition, and in the succeeding intervals becomes more and more impaired until, in the majority of cases, complete mental disorganization or dementia closes the scene in a few years. These are the cases of dementia præcox.

In the other class the attacks are usually relatively short (from six to twelve months); they occur in the main at fairly regular, periodical intervals; they are never other than mania or melancholia in their nature, and the intervals are characterized by complete return to reason and normal health. The intervals, moreover, are in some cases of long duration, lasting it may be for years. In many instances the combined duration of all the attacks represents but a small proportion of a patient's lifetime. It is safe to say that, excepting in circular insanity, it is only a minority of cases of this form in which the attacks occur within two years of each other, although they are likely to recur more frequently with advancing years. It is, however, impossible to predict the length of the intervals, as they are more or less irregular, although it may be approximated after several attacks have occurred. This form is now known as manic-depressive insanity.

It is obvious, therefore, that the difference in the outcome of these two varieties is a wide and important one. At the same time it is sometimes exceedingly difficult to distinguish between them before a second attack has occurred. Nothing can emphasize more strongly than these groups of cases the necessity of a correct diagnosis as a preliminary to even a fairly accurate prognosis in mental disease. These indications are fully considered in special articles below on manic-depressive insanity and dementia præcox, where will also be found the prognostic indications relating to the subordinate states of mental disturbances, such as mania, melancholia, stupor, confusion, and the like, which distinguish these diseases.

Heredity.—The chief element in the prognosis of mental disease is faulty heredity. This is the most prominent factor in the causation of idiocy and imbecility and of the different forms which degenerative insanity assumes. Those included under this head in the HANDBOOK are: paranoia, manic-depressive insanity, circular insanity, the constitutional psychopathic states, including congenital neurasthenia, compulsive insanity, impulsive insanity, and contrary sexual instincts; also "moral" insanity and *folie à deux*. When any of these conditions are unmistakable the disease is sure to be of the chronic type, whether its progress is uniformly degenerative or manifested by periodical attacks.

It is not an uncommon belief among non-medical people and even general physicians that the inheritance of insanity means impossibility of recovery in any sense from an attack of insanity. On the contrary, so far as the attack goes, certain strongly hereditary cases make, as has been shown, good recoveries, although they are more liable to relapse than are those in which the hereditary tendency to disease of the mind is absent. A bad family tendency to insanity may be shown in actual and marked insanity of certain members, while the rest are sound and strong and appear to have the normal amount of resistive power to disease. This, however, is a better inheritance than less distinct mental disease and more unsoundness and a low state of mental and bodily health *in the family generally* in the forms, for example, of various neurotic disorders, convulsions in childhood, weakmindedness, bad habits and propensities, and physical defects.

*General paralysis of the insane,** also known as paretic dementia, general paresis, and popularly as "paresis," is, it can be safely said, invariably fatal. There are, to be sure, a few, very few, examples of recovery reported by competent observers; but they are not by any means incontestable, while the usual alleged cures are either due to faulty diagnosis or are the result of premature conclusions during some remission in its course. The disease has certain features alluded to in but few text-books, the proper interpretation of which is essential to a correct diagnosis. It is a frequent experience of the alienist to find that favorable prognoses have been made in cases of general paresis by general physicians who have mistaken for ordinary insanity attacks of "mania" or "melancholia" that are really of paretic origin, and which, far from being idiopathic, functional psychoses, are simply symptomatic groups or syndromes occurring in the course of the grave structural disorder of the brain—general paresis. As mania, and especially melancholia, have the same manifestations, whether occurring independently or in the course of general paresis, it is not surprising that such errors occur where the opportunity for observation is necessarily so limited as is the case in general practice. It is also a common error to mistake the incipient stage of general paresis for neurasthenia or hypochondriasis, so closely does it simulate these disorders in many cases. The consequent prognosis may lead to serious results, for, as Berkley points out,† what slight hope there may be in the treatment of paresis can obtain only in those cases in which the therapeutic measures are undertaken in the earliest stage of the affection; added to this, its early recognition is necessary to protect the family of the patient from serious ethical and financial misadventures as well as from possible brutalities.

The duration of general paresis is often perplexing; and although we may rightly say in the majority of cases that the end may come at any time within three or four years from the onset of active symptoms at the furthest, according to the kind of care the patient receives, the nature of the attack, or the severity of the intercurrent affections to which it predisposes its victims, there is considerable variation in the length of its different stages, whether of remission or of progress. We also meet with surprises occasionally in the way of temporary recuperative changes, both mental and physical, which are little short of startling, and which it would have seemed folly to predict. When epileptic seizures are frequent and are a marked feature from the first, there is great danger that the patient will be cut off by a series of them in the form of the epileptic status.

But it is the stage of remission in general paresis which is responsible for most of the mistakes of diagnosis and prognosis that are made in this disorder, as only the trained observer can find evidences of mental failure in many of these patients, who at this stage may appear to their relatives to be entirely well. That, however, an exacerbation is sure to follow sooner or later, in spite of this apparent return to health, and that only by the most careful and quiet living can it be long delayed, is the only opinion to be given that is consistent with fact. It is often months, and occasionally years, before the signs of degeneration recommence and our prognosis is finally verified.

The Time of Life at which insanity occurs also modifies the prognosis; as in physical so in mental disease the young, especially females, are far more likely to recover than the mature and the old. It has been estimated that sixty-three per cent. of the "recoveries" from insanity take place before the age of twenty-five. At the same time the young are more subject to relapses, and it is at

* See article on *General Paralysis*, p. 86 of the present volume.
† Berkley's "Mental Diseases," p. 464, first edition.

this time of life almost exclusively that dementia præcox appears

The menopause is another period of life at which many cases of insanity recover; but the disease is usually of long duration, not ending until the cessation of the menstrual function is complete. It must be borne in mind, however, that genuine "climacteric insanity" is rare, as cases in which the menopause is unmistakably the sole or even the chief cause of the trouble are far less common than is usually supposed.* Melancholia of involution is now thought to cover most of these cases. Predisposition to mental disease occurring at this time, is the rule, but the insanity is also largely due to diminished vigor of body and mind generally and the failure of the system properly to readjust its powers to meet the changed conditions rather than to any local change. This form of insanity not infrequently appears as the single attack of a lifetime, and, with confusional insanity in the mature, forms the bulk of permanent recoveries.

Old age, on the contrary, is obviously the most unfavorable time for an attack of insanity; but here it is death from exhaustion that is to be feared rather than death of the mind alone. Even at this time of life, however, there is risk in predicting that recovery is impossible, as it is among the aged that the marvellous cases are occasionally met with of complete cure of acute melancholia in which exhaustion seemed inevitable from the extreme agitation, depression, refusal of food, and consequent emaciation. Such miracles have few counterparts in physical disease.†

The Physical Condition before the trouble begins is, if good, a less favorable sign than might be supposed, as it is the mild, slowly developing case with gradual and permanent mental deterioration in which the bodily health is but little disturbed. On the other hand, the acute, severe, rapidly culminating, and for the most part presumably curable cases are often preceded by a season of reduced physical health and strength and loss of flesh, which continues throughout the acute stage.

The Natural Mental Capacity also makes quite a decided difference in our prognosis, as a person with a strong and active intellect and even keen sensibilities before the attack, seems to offer greater resistive powers to disorders of the mind when once established than does an imperfectly developed mind and an insentient nature. The immediate cause of an attack, when well limited and appreciable, which is not often the case, indicates a good chance of recovery; for example, sudden bereavement, shock, accident, money loss, the puerperal state, lactation, etc.

Treatment affects the prognosis in no small degree, especially the time of its adoption, the patient's chances growing fewer the longer it is delayed. It is needless to emphasize by statistics this well-established and well-known fact of the importance of early treatment (not necessarily that of an asylum) away from home. The kind of treatment also has a decided influence; and the greater prevalence, both within and outside of institutions for the insane, of care and treatment directed to the needs of the individual patient, is sure to be a most potent factor in increasing the number of cures, or at least in preventing relapses and relieving the chronic cases. The practice which is still largely unavoidable in public institutions for the insane, of placing acutely violent patients in a perhaps overcrowded ward for obnoxious and equally excited patients in different stages and forms of insanity, as well as of different classes of society it may be, can but retard, if it does not actually prevent, recovery in many cases.

The Minor Conditions of an Attack of Insanity and its individual symptoms often tempt us to predict the outcome; but it is a hazardous practice. There are many, however, that are useful to know when properly estimated —like minor symptoms of physical disorders—as simply corroborative indications. Of this order is the important prognostic point that is furnished by the way in which an attack begins, as in general a quick onset means a fairly quick recovery, excepting of course cases of *delirium grave*, otherwise known as typhomania and as acute delirious mania or melancholia, a form which is extremely dangerous to life, especially in old people. *Per contra*, a long antecedent period of mild mental symptoms or peculiar conduct betokens chronicity.

Another indication that is quite reliable is the familiar one that when improved nutrition keeps pace with the mental gain, as evidenced by the patient's weight, the chances of recovery are good, while an improved physical condition unattended by mental improvement, or *vice versa*, is a bad omen. Marked and protracted hallucinations of hearing, especially when they develop late; the creation of new words; the adoption of a pathological language—of a peculiar costume; a tendency to self-decoration, special attitudes, hoarding, etc., mean, as a rule, incurability. Incoherence and persistent delusions without excitement are usually signs of confirmed mental weakness (Kirchoff). This is frequent in hebephrenia. Absence of the feeling of satiety, eating or drinking nauseous articles, are usually found in unfavorable cases. In continued sexual excitement recovery is rare; but the practice of masturbation, if discontinued, may not interfere with recovery.

Among the surest indications of recovery is the recognition of former delusions as such.

The intervals of calm and rationality which suddenly and unexpectedly occur, especially in cases of melancholia and confusional insanity, are very deceptive, and often tempt one to make a prognosis of speedy recovery that is soon found to have been premature. It is only when these sudden recoveries of reason follow a period of decided gain in sleep and general health that they are permanent as a rule. Generally speaking, the mind is clouded over again in a day or two, and the disease runs its course with renewed intensity. It is safe, nevertheless, to predict that *ultimate* recovery is probable in cases that are characterized by such intervals of rationality.

When hypochondriacal delusions are a marked feature of a case, the outlook is bad, especially if the subject is advanced in years.

Persistent refusal of food, especially when due to hypochondriacal delusions and when prolonged, is an unfavorable sign. Recoveries may occur in such cases, as in other extreme conditions; but they are as rare as they are surprising.

"Mild" cases of melancholia, which are apt to be treated at home, are very deceptive in respect to the probability of suicide; and the more rational the patient the more crafty and deliberate he will often be in carrying out his plans. It not infrequently happens in such cases that a desperate attempt at self-destruction is the first warning given the family or the physician of the suicidal propensity. Careful and frequent examination of the patient's line of thought will usually reveal the desire for suicide, after which it is a grave risk to attempt to give such a patient proper supervision at home. The desperate and violently determined melancholiac, whose efforts are constant and unremitting owing to the strength of the suicidal impulse and in whom there is little sign of reason, is doomed to dementia unless there be an early turn in the disease.

The suicidal tendency is often looked upon by people in general, as a particularly ominous feature as regards recovery, whereas it is a frequent and logical manifestation of a curable form of insanity—melancholia. The chief danger is, of course, to life, before proper measures for the patient's protection have been taken, after which his chance for recovery is quite as good as that of any case of melancholia without such tendencies.

Finally, the best recoveries are seldom perfect, and a large proportion fail to recover their former mental condition in full. As it has been well put by Folsom:* "There is left some change of character, no matter how

* See *Climacteric Insanity and Melancholia*, below.
† See *Senile Insanity*, below.

* "Mental Diseases," p. 127.

slight, some moral perversion, irritability, impaired will, lessened power of self-control, diminished mental capacity—some lowering of the intellectual or moral standard, some deterioration of some kind." This is also true of the physical condition, which in many cases never fully returns, and the power of endurance especially proves to be much diminished.

Regarding prognosis as to life, it may be said that, excluding the suicidally inclined, in relatively few cases is death to be feared as a direct consequence of insanity that is not organic, *e.g.*, general paresis, senile cases, and those consequent on focal lesions. The others are largely from one group—the delirious manias—the form of death being exhaustion from continuous, intense, and often febrile excitement. Death is much more likely to take place in the beginning of an attack, as that is the time of greatest violence and strain. It is then, too, that refusal of food and suicidal attempts are most common.

Henry R. Stedman.

VIII. INSANITY: GENERAL TREATMENT AND CARE OF THE INSANE.—The scope of this general article on the treatment of insanity is shown by the following headings under which the subject will be presented, viz.: (1) Prevention and State Medicine; (2) Treatment and Care in Institutions and in Private; (3) General Emergencies in Psychiatry; (4) Medication; (5) Surgical Measures; (6) Psychiatric Hygiene (Hydrotherapy and Climatotherapy included); (7) Dietetics; (8) Mental Therapeutics; (9) Convalescence and Protective Aid. The treatment of the special forms of mental disease will be considered in various separate articles by different authors.

Prevention and State Medicine.—Broad preventive treatment of insanity has never been undertaken, but it is time for some concert of opinion and action between physicians and lawmakers to control such causes of the disease as exist widely in the whole fabric of society. Heredity as a chief source might be diminished in a measure by the enactment of wise marriage laws, prohibiting the reproduction of the kind *in vinculo matrimonii* by idiots, imbeciles, lunatics actual or imperfectly recovered, confirmed epileptics, the chronically alcoholized, and neurotic subjects with a double parental taint of lunacy. The State, financially burdened with the increasing numbers of her insane wards, should adopt various wide and far-sighted measures of prophylaxis. The standard of knowledge of mental disease in the medical profession should be raised. Thorough and practical instead of nominal instruction in psychiatry should be made compulsory in all medical schools, and medical degrees or licenses should not be granted on State examinations to those incompetent in this branch, for in nine cases out of ten the general practitioner has to solve alienistic problems without the help of the mental expert. The State should disseminate widely by free literature and lectures common-sense ideas of the nature and causes of insanity, of the means of its avoidance, and seek to remove the false dread and stigma which tend to hide the disease until it is past cure. In all the largest cities the State should establish hospitals for the clinical observation and continued treatment of incipient and other forms of mental disease without legal formalities or financial obstructions. The officers of such hospitals, known for their skill in nervous and mental diseases, should give prophylactic advice as to feeble children, exceptional curriculum of studies in schools, permissible marriages, and all the adult relations of life in neurotic families.

Treatment and Care in Institutions and in Private.—It would appear from late census returns in this and other countries that about seventy per cent. of those mentally defective and insane are cared for in institutions. Large numbers, however, escape recognition and enumeration.

Colonies are among the best provisions for the insane. The oldest is at Gheel, Belgium, agricultural and under medical and governmental control. Another successful colony is at Clermont-sur-Oise, France. In connection with a central institution agricultural colonies also exist at Alt-Scherbitz, Saxony, Ellen near Bremen, Slup near Prague, Ilten near Hanover, and at Reggio-Emilia, Italy.

The Family System of the boarding out of the insane in private families has long been found practical in Scotland and in Massachusetts and Wisconsin also.

Hospitals for the insane, well organized under public supervision, exist in most of the States, and some have a cottage system and agricultural colony provisions. Their chief defects are overcrowding and lack of special wards and adequate means of treatment of acute cases and of the criminal and epileptic insane. Private hospitals for the mentally diseased are found in most of the States. Some of them are officered by mental experts, and are indispensable resorts for those wishing to avoid public hospitals and unable for various reasons to be treated in their own homes. There are also unlicensed sanatoria, water cures, hygienic hotels, and health resorts, more or less well conducted, in which the insane unfortunately often remain until their best chances of cure have passed. The family physician in the majority of instances will have to consign his mental sufferers to the public hospitals for reliable cure at a moderate rate, but exceptionally the means of the patient will admit of the choice of a well-appointed private hospital with trained nurses, few patients, and the comforts of home and completely individualized treatment. Treatment in private at the patient's house is expensive, in view of fees of nurses and physician expert, and it sometimes reacts banefully on the whole household; while, on the other hand, cure at home avoids publicity and some of the dread stigma of the disease. The physician must isolate the patient in some part of the house, and guard against suicide and violence by constant supervision of trained nurses, and if the case prove too troublesome a resort at once to a private hospital is better than attempts to improvise hospital facilities in hotels and boarding-houses.

General Emergencies in Psychiatry.—There are certain very urgent conditions in mental disease constituting positive emergencies to be met by prompt treatment. Inanition is one of the most common of these conditions, and it is often not diagnosed until it has reached a degree dangerous to the life of the patient or at least to the prospect of early recovery of brain cells, which degenerate rapidly during acute malnutrition. The waste of tissues in active mental disease is excessive, and a surprising amount of concentrated nourishment is needed to sustain the patient, who may be said by the friends to have eaten pretty well and yet the breath may have a real starvation odor. The best foodstuffs and means of forced alimentation will be described under the head of dietetics. If the case borders on collapse, nutrient and stimulating enemata and the injection of saline solutions under the skin may be practised. Another almost constant emergency in acute insanity is insomnia, and it may lead to a fatal issue as surely as starvation and is not always recognized. Sleep is often feigned, or it is fitful and dreamful and partial to a degree which does not admit of that complete restoration of nervous forces which occurs only during physiological repose of cortical centres. In feeble patients one of the best aids to sleep is long exposure in the open air, and the gentle motion of an easy carriage also favors it. In muscular subjects active exertion out of doors may be effective. Heat and cold, dry or moist, skilfully applied to the head, spine, epigastrium, or extremities, often produce sleep. Other means are warm baths with cold to the head, hot or cold packs with massage, liquid nourishment or hot drinks at bedtime with a cool bedroom and long bed-hours, and a siesta in the daytime if possible as a preparation for the night's sleep. The lower bowel should be emptied by enemata before the retiring hour, and in persons of full habit an active purge may prove the best somnifacient. The most obstinate agrypniais often due to auto-intoxication, and intestinal antisepsis should then be used after a full dose of calomel.

Obstipation in some cases is an emergency which pre-

vents physical improvement, and cannot be successfully met by ordinary enemata or purges, and requires intestinal lavage and often mechanical delivery of the impacted fæces.

In forty per cent. of acute cases of insanity there exists an emergency from the impulse to suicide or violence of some form. Drugs may abate these violent tendencies, but cannot control them except when continuously administered in harmful doses. The only way to meet this emergency is by the incessant supervision of experienced and vigilant nurses. This surveillance will be regarded as an imposition by the patient, who will likely have the sympathy of relatives, but the physician will rue the day if sentiment displaces judgment in these cases.

An emergency which is fatal in a considerable percentage of acute attacks of mental disease is general exhaustion of vital powers, which often escapes notice, owing to a false show of strength on the part of the patient, who may walk about the very hour in which he falls in final collapse. Prodromal symptoms are haggard looks, subnormal temperature, and feeble and irregular heart's action. Patients with such signs are to be at once placed and kept in the recumbent posture, warmed by artificial heat, nourished by concentrated liquid food in small and frequent quantities, and given brandy and strychnine hypodermatically if cardiac failure be imminent.

Medication.—The therapy of insanity is as extended as the vast number of diseased conditions which bear a causative relation to the mental malady. Thus the diatheses, the toxic and autotoxic states, the established neuroses, gross disease of brain, spine, thoracic, abdominal or pelvic organs, and all other etiological factors furnish direct and extremely varied indications for medication. The general practitioner may be assured that there are no specifics in psychiatry, and that the treatment can best proceed only on the broad lines of general therapeutics, and success will correspond precisely to the skill displayed in the general use of drugs and in the scientific diagnosis of pathological physical conditions. In the first place, urgent symptoms described under the last heading as emergencies in psychiatry are to be met. Secondly, all diseased states standing in the light of causes to the insanity are to be combated by appropriate remedies. Thirdly, symptomatic indications as they arise and the hygienic requirements of the case are to govern the continued treatment.

A brief and practical summary of the best drugs and their chief uses in psychiatric practice is here given.

Hypnotics.—Chloral hydrate produces sleep more constantly than other drugs, and may be given alone or combined with morphine or bromide of potassium. It is in full doses depressant of circulation, respiration, and digestion, and is not advisable in cardiac and renal disease. In obstinate agrypnia it is better used only on alternate nights in full doses.

The bromides of potassium, sodium, and strontium have a relative hypnotic value in the order mentioned, and are effective in acute mental disease only in large doses. Their action is sometimes heightened by the addition of ergot or cannabis indica.

Opium and its alkaloids relieve pain while they produce sleep, and are occasionally useful on this account, but both tolerance of the drug and a drug habit are readily established.

Paraldehyde acts with certainty and celerity as a hypnotic, but it makes the breath and the stools offensive, and in continued doses it is not free from toxic results.

Sulphonal has decided hypnotic effects, but they are delayed often for many hours, and unfortunately it is cumulative and dangerously depressing in continued use. The allied drugs, trional and tetronal, are more prompt as somnifacients, but if prolonged they have toxic results like sulphonal.

Hyoscine and hyoscyamine should be used only in strong maniacal patients. They are powerful nervous depressants and not properly hypnotics. Incidentally they cause sleep in a few moments in some cases, but completely fail in others.

Methylal, somnal, chloralose, hypnal, chloralamide, and other proposed hypnotics are by no means as reliable as those already named.

Tonics.—Iron is indicated for the anæmia so constant in mental diseases. It is a routine remedy often given in too large doses, and should be administered with discrimination in small and continued portions, and never on an empty stomach. Its use should be temporarily discontinued on the appearance of gastro-intestinal irritation. Of the vast number of ferruginous preparations none is more reliable than the old tinct. ferri chloridi.

Cinchona and its alkaloids are useful, especially in a large percentage of mental sufferers having a history of malarial attacks even though remote. The mental excitement may even mask the plasmodial crisis, and quinine in full doses will prove most efficacious.

Strychnine in all the toxic insanities is the best tonic, and is of use also in the neurasthenic cases given until its physiological action is evident. Even in cases with gross lesions of the nervous system it may be cautiously employed to advantage.

Arsenic in choreic, malarial, and phthisical insanity and in some other diathetic and toxic forms is a good tonic.

Phosphorus is theoretically indicated in mental disease, and is practically of some real tonic value.

Alteratives and Eliminatives.—Mercury in some of its forms is indispensable in syphilitic insanity, and in urgent cases mercurial inunctions and baths are to be employed. The iodide of potassium is often indicated as an alterative in luetic cases and as an eliminative in toxic psychoses. Iodine, cod-liver oil, and lithium also deserve nominal notice.

Purgatives.—In all forms of mental depression there is a tendency to constipation from diminished peristalsis and secretions. The gastro-intestinal tract is often foul and a source of autotoxis, and it is then well to begin treatment with a full dose of calomel and a saline purge, and subsequently to effect intestinal antisepsis by means of salol or salophen. Oleum tiglii is useful in obstipation, in the apoplectic, epileptic, or paretic status, and after ordinary purgatives fail. In maniacs of full habit colocynth or elaterium relieves plethora and favors sedation, and alvine discharges are then to be regulated by laxatives and intestinal lavage.

Emetics.—When mustard and sulphate of zinc fail and the stomach pump is resisted, a fresh solution of apomorphinæ hydrochloras administered hypodermically is the most prompt emetic. Ipecac relieves the violence and the foul stomach of strong maniacs, and incidentally is often a better sedative than some motor depressants in vogue.

Vascular Sedatives and Stimulants.—The cerebral hyperæmia of sthenic maniacs and the violent cardiac action are partly to be controlled by aconite, and if there be inflammatory cerebral membranes antimony may be conjoined to advantage. The best cardiac stimulant is alcohol, and its most prompt vascular effect is to be had by the hypodermatic use of brandy. Digitalis and belladonna are also valuable.

Nervous Sedatives.—Opium is the best nervous sedative in precordial panic, painful delusive states, senile agitation, and in all kinds of anguish common to the insane. Doses must be increased, and it is never wise to substitute an opium habit for a psychosis. Other sedatives of occasional value are chloral, the bromides, cannabis indica, camphor monobromate, lupulin, and valerian in milder cases; and in powerful maniacs conium, gelsemium, or veratrum viride may be cautiously employed. Organotherapy has been tried, but testin, cardin, cerebrin, ovarin, tuberculin, and other extracts have given no satisfaction, though thyroid extract in myxœdematous insanity is of use.

Surgical Measures.—The insane are entitled to such relief as surgical science may afford. The transient aggravation of mental symptoms which a surgical operation may occasion is insignificant if a causative condition or an obstacle to recovery be removed. It is high time for a wide application of conservative surgery in psychi-

atric practice, and obstructive prejudice must give way to modern science as often as an etiological factor of the mental disease can be removed by the surgical measure, and the patient chance to be in physical condition to bear the operation.

Trephining may be necessary among the insane with cranial fracture and depression, neoplasms of brain membranes, cerebral tumors or abscesses, and penetration by bullets or other foreign bodies.

Craniotomy in arrest of mental development from premature closure of cranial sutures, vertebral puncture in paresis, thyroidectomy in the insanity of Graves' disease, circumcision in masturbatic cases, and phlebotomy in sthenic maniacs with cerebral hyperæmia are all operations to be decided upon according to the individual indications in each case.

Transfusion might be tried with reasonable hope of success in puerperal insanity with post-partum hemorrhage and in various persistent anæmic cases. Hypodermoclysis is a practical surgical measure in toxic insanity to assist elimination, and also in all states of extreme inanition. Diseases of the organs of special sense may cause or aggravate the insanity, and hence ophthalmic, aural, and other special forms of surgery become necessary. Dental surgery is of importance for the health and comfort of patients, and in every hospital for the insane a competent dentist should render the necessary services.

Troublesome hernias, urethral strictures, varicoceles, hydroceles, and hemorrhoids should have prompt surgical treatment.

The simple fact of insanity does not alter the general indications or principles of gynecological surgery. The diseased uterus and its adnexa must receive due surgical treatment, and even hysterectomy and oöphorectomy are justifiable in certain cases. It is a mistake to suppose that the most confirmed masturbatic habit justifies clitoridectomy or orchidectomy, since the irritative source of the sexual excitement in most of these cases is in the cerebral cortex.

There are a host of minor surgical operations which should be performed to relieve physical discomfort or pain or to improve the general health of the patient. The rules as to local or general anæsthesia are the same as in health. Anæsthesia may also be required in epileptic, paretic, or puerperal convulsive conditions, or to determine the real state of things in hysterical or feigned insanity, but it is not to be used to suppress maniacal excitement. Vesication, the thermocautery, the electrocautery, acupuncture, and the use of setons all have a legitimate application in occasional cases of insanity.

Electrotherapy is a surgical measure not to be trusted to nurses or even to physicians not skilled in its use.

Galvanism is the form of electricity of widest advantage in psychiatry for sedative, trophic, or antineuralgic action, and for electro-diagnosis. A course of electrical treatment should extend over some weeks, and desultory séances are only for psychical effect. General galvanization with currents of low electromotive force are most suitable in states of mental depression and to relieve the hyperæsthesias of neurasthenic cases. Galvanization of the cervical sympathetic in anæmic states of stupor may favorably influence the circulation and the spastic capillaries, while cerebral galvanization may be practised with caution for sedative and soporific effects. Large electrodes and powerful currents are needed for the spinal cord, and galvanization of special organs is hardly practical.

Faradism has qualitative variations determined chiefly by the length of coils, size of wires, and number of interruptions. Long coils, fine wires, and rapid interruptions give a smooth current suitable in neurasthenic and feeble persons. General faradization is most advantageous in melancholic and stuporous conditions, and the hand of the operator is the best electrode in these cases. To arouse strong patients from apathy and muscular inertia larger wires, shorter coils, and fewer interruptions may be used, or the electric brush may be tried. In a vast number of cases refusing to take active exercise faradism may be employed to advantage in the form of electric massage.

Static electricity is chiefly adapted to the production of mental effects in psychiatric practice, and as a stimulant of the sensory peripheral nervous system. Hypochondriacs and neurasthenics mounting the insulated stool before an imposing static machine, and taking the electrical breeze or having sparks drawn from parts which are the seat of imaginary pains, undergo a good form of psychotherapy as well as counter-irritation and capillary stimulation.

In general, however, franklinism is of less use in mental diseases than galvanism or faradism.

Electrotherapy among patients very often hyperæsthetic or anæsthetic must be practised with an initial minimum dosage gradually increased to the desired strength, to be determined less by milliamperage than by actual effects produced.

Psychiatric Hygiene.—Under this head something will be said of hydrotherapy and climatotherapy also. The hygiene of the residence is of prime importance. The habitation should be in a healthful locality, well drained, lighted, and ventilated, and with sunny rooms in winter at least. The hot-water system of heating is best, and open fireplaces are excellent auxiliaries for warming and changing the air. Hardwood and parquet floors are best in sleeping-rooms, which should have only necessary articles of furniture and an iron bedstead with hair and woven wire mattress and fine woollen blankets. The bed is to be made a place of comfort, and feeble, rheumatic, and neuralgic patients often sleep best between woollen blankets in winter, and water and air beds are an occasional necessity. Most of the insane have impaired vitality and circulation and need warm underwear. Various minor points in the hygiene of the person determine the major point of bodily comfort or distress. Thus the skin requires special cleanliness, and is subject to various eruptions in mental disease. The mouth must be treated with antiseptic washes for offensive breath and bacterial growths, while tartar and dental caries are to be removed by a dentist. A habit of the regular relief of bowels and bladder must be established, with special attention to local cleanliness even in the most apathetic cases.

Out-of-door life is a hygienic measure never to be neglected, and porches, tents, summer-houses, cots, and hammocks are to be utilized, and carriages are available in feeble cases. The rest-cure in bed is good in senile and acutely exhausted patients, but the opposite course is generally best for the great majority of the insane, who derive benefit from customary out-of-door occupations, or from walking, horseback-riding, cycling, or golfing. In bad weather indoor games, gymnastics, and massage are to be employed.

Climatotherapy is of special import in psychiatry. The neurasthenic insane do best in northern mountainous regions in summer and in southern climes for outdoor life in winter, where the greatest number of sunny days are to be had with avoidance of extremes of temperature. The senile insane do best in mild climates under high rather than low barometric pressure. The phthisical insane do well in mountainous localities until pulmonary lesions are advanced, when marine climates are preferable. In all mental disease with gross brain lesions, cardiac affections, or diathetic and toxic conditions, rarefaction of air and great diminution of barometric pressure are to be avoided. Residents of large cities benefit by a change to country air; watering-places sometimes combine pure air and water; and foreigners profit by a change to their native climate, and mental sufferers generally do well to avoid the uncertainties and perplexities of foreign travel.

Hydrotherapy in mental diseases is as ancient as Hippocrates, but it is only of late that hospitals for the insane have made some suitable provisions for it. As physician in charge of New York City Asylum for the Insane, the writer first in America made extensive use of

the Turkish bath, and published the results of various forms of insanity thus treated in his annual report for 1874, and a few years later printed a monographic article on "Hydrotherapy in Insanity," and for more information than space will here permit reference may be had to the writer's "Text-Book of Mental Diseases," pp. 459–474. The physiological principles of all hydrotherapy are that heat and cold to the surface of the body may be made to expand or contract the capillaries, to increase or diminish cardiac action, bodily temperature, respiration, secretion, and general metabolism. Among the insane these effects are best obtained by warm rather than cold applications, to be regulated by reliable thermometers under the observation of physicians rather than nurses. Sedation of maniacal excitement and relaxation of vaso-spasm in melancholic stupor are better accomplished by warm than cold baths, just as stimulation of the cutaneous periphery or of the whole nervous system in apathetic states is most promptly effected by hot rather than cold douches. Motor and mental agitation in hyperacute mania may often be controlled by baths graduated from warm to cool, and prolonged from one to two hours, and repeated once or twice in twenty-four hours in strong patients with sound heart and lungs.

The Turkish bath is more generally applicable than any other in mental diseases. It can be used in the old and the young, in the neurasthenic and melancholic and debilitated, as well as in the strong and maniacal. In toxic cases it increases cutaneous excretion, and it restores the impaired capillary circulation in melancholiacs, and the subnormal temperature in stuporous patients, and in acute alcoholic states it is excellent for both its eliminative and sedative action. It is of wide service too in diathetic insanity; for the syphilitic, phthisical, Brightic, rheumatic, malarial, and podagrous cases all profit by a judicious use of the Turkish bath, and only decided cardiac or pulmonary lesions are contraindications.

Swim baths, sitz baths, foot baths, spray baths, douches (hot, cold, spinal, and Scottish), medicated and Russian baths, drip sheets, and wet packs of all kinds have an occasional special utility in psychiatry, especially when combined with skilful massage. In hyperpyrexia of delirium acutum, of the paretic or epileptic status, or of toxic maniacal states, the cold affusion may be used to great advantage when friction of surfaces with ice proves inadequate.

Dietetics in mental disease present difficult practical problems. The waste of tissues and need of nourishment are maximum in degree, while appetite and assimilative power are minimum in the acute insanities. A full ration of albuminates, fats, and carbohydrates must be at once enforced, and foods are to be prepared in varied and appetizing form with due regard to individual tastes. In general there is nothing better than fresh milks, eggs, meats, and fruits in season. The nutritive value of preserved foods and liquid preparations of meat is overrated, and shredded or scraped fresh meat should be given in pulp, which may be mixed with liquids to be fed through tubes. Predigested foods, rectal alimentation, and subcutaneous injections of saline solutions are only extreme resorts. Anorexia and foul tongue should not deter the physician from forced feeding, best done by nasal tubes with the patient seated, though œsophageal tubes or stomach pump are at times necessary. Meat pulp and vegetables in form of purée and juices of fresh fruits may be thus given in amounts twenty per cent. above average rations, for inanition is a constant danger. In chronic and incurable lunacy stinting of food supplies is justifiable economy, but it is bad state policy to withhold generous diet in recoverable cases, and chronicity is often due to defects of feeding in the curable stage.

Mental Therapeutics.—By this term is understood all those means which directly modify the thoughts, feelings, and emotional states of the patient. In mental disease, as in health, psychic influences continue powerful for good or evil. The patient is first to be removed from the scene of his delusions, from business worry and domestic strife, to an agreeable environment, there to receive the most decided of all psychotherapeutic effects, which is the sympathy and advice of an intelligent physician. Next to the physician the nurse is the constant medium for psychic influences, and should be chosen to suit the patient and also the phases of the mental malady. In the convalescent stage companion nurses, educated and refined in manner, are most useful psychotherapeutic agents. The regularity, discipline, force of example, and confidence inspired by numbers make institutional care effective in the moral treatment of the insane in the majority of cases. Occupation, not forced but customary and of interest to the patient, is a most reliable psychic remedy, and the more useful it is the more serious is the purpose of cure which it serves. Diversions varied and well timed to the occasional moods of the malady play an important rôle in mental therapeutics. Outdoor sports are preferable, but indoor games are available more months in the year.

During convalescence there should be a gradual restoration of the social life of the patient, a renewal of friendships with the nearest relatives, and such hospitality as will restore the self-respect of the patient, and the influence of the opposite sex is not to be ignored.

Religion may be allowed to "minister to a mind diseased," though the religious delusions of some patients forbid it.

Discipline, rewards, and corrective advice are to correspond to the modified responsibility of the insane, who are to be granted or denied privileges, and to encounter moral restraints such as may aid them to suppress insane impulses. The solitary confinement of a violent lunatic is not justified as a punitive measure, but for its psychic effect. The principle of non-restraint is universally indorsed, but some protection from violence is necessary. There are three forms of restraint—chemical, manual, and mechanical. Chemical restraint by powerful drugs is most often used and abused. Manual restraint by the hands of nurses is necessary sometimes and also liable to abuse. Mechanical restraint is best done by a restraining sheet in surgical and violent cases apt to be bruised by persistent resistance to nurses. In the vast majority of even acute cases no restraint of any kind is needed. Hypnotism is not recommended in any class of cases, but therapeutic suggestion of ideas by the physician seconded by nurses may favorably influence the thoughts and conduct of patients; and likewise placebos are of occasional advantage in mental therapeutics.

Convalescence and Protective Aid.—Recovery from insanity is often apparent before it is real, and though importuned by relatives the practical alienist will not return the patient to business and social life prematurely, and run the risk of a relapse and possible incurability. In case of imperfect recovery the physician has to decide the degree of restoration of the financial rights and the business competency of the patient. Those convalesced with mental defect, capable of self-care and not dangerous to self or others, are legally entitled to personal freedom.

Protective aid for those discharged from institutional care improved only is a desideratum. The writer some years ago published the view that the State should establish a "Bureau of Protective Aid" for patients discharged from institutions as well as for those under great stress of any kind liable to end in insanity. In this way the stigma of insanity would not block the way to self-support of convalescents, and many harmless and industrious inmates of institutions might be returned to the outside world, and the actual public burden of enormous numbers of imperfectly recovered insane might be in a measure reduced.

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IX. INSANITY, MEDICO-LEGAL ASPECTS OF.— Insanity is a disease so often affecting the knowledge of right and wrong by its disturbance of the mental faculties that it is viewed from the standpoint of both medicine and law. The following is a comprehensive medical definition of the term: "Insanity is a condition produced

by disease, in which there is a prolonged departure from one's natural ways of thinking and acting." This definition is broad enough to cover all forms of lunacy, but it does not include idiocy, or imbecility, or the natural impairment of old age, neither does it embrace transient delirium, nor the brief periods of alcoholic or other intoxications. The courts, however, recognize the existence of mental enfeeblement in many instances wherein the patient is not in a medical sense insane, and properly employ the term unsoundness of mind as an expression of wider meaning. This does not always signify mental incapacity. The phrase "non compos mentis" of older origin, meaning no control of mind, is stronger, more definite, and indicates incompetency. The legal test of responsibility aims to determine whether a person committing an act knew the nature and quality of the act, or that the act was wrong, and whether he was so impelled by stress of disease as to have been unable to refrain from committing it. Medicine and law have ever been somewhat at variance, particularly in matters relating to criminal responsibility. The modern acceptance of the doctrine of criminal responsibility may be summed up as follows: "Was the person whose act is in question able to understand its nature, and to pass a fairly rational judgment on its consequences to himself and others, and was he a free agent so far as that act was concerned?"

This is the basis upon which at present rests the legal analysis of a man's responsibility for his acts. It should be remembered that the knowledge of the act must pertain to the particular one in question, and not to those of a similar character. Concerning abstract acts in general, a person may have very clear ideas as to right and wrong, but in relation to his own deed at a stated time he may entertain false and most erroneous beliefs. The law requires that he must know the nature of his act—in other words, its physical character, whether it was, for example, an act of assault, of killing, of appropriating property, or of kindling a fire; that is, he must understand the material essence of what he was doing at the time. He also must know the quality of his act, whether, for instance, an assault was in self-defence, for revenge, jealousy, or any other assignable motive; whether in appropriating property he was taking that which he believed to be his own, or was engaged in theft or robbery; whether his purpose in setting a fire was arson, or properly to promote warmth and comfort for himself and others. The quality of an act is determined by the mental processes which lead up to its committal. It is important to discover the premises from which his reasoning starts. His train of thought, though apparently logical, may have some delusional idea as its origin. The underlying motive, therefore, should be considered in order to form a correct judgment. In short, was the person actuated by a rational impulse, or was he controlled by a diseased mind?

An idiot, imbecile, epileptic, or a demented person may act without apparent motive and have no knowledge whatever of the nature and quality of the act, or he may even be entirely ignorant of having committed it.

As a further test, a person to be irresponsible must be so incapacitated as not to know that an act was wrong; that is, morally wrong. It is not necessary that he should have a fine ethical sense, but he should understand that the act in question was a wrongful act for him to do, and should reasonably understand its consequences to himself and others. It is not essential that he should know that the act was against the law of the land, for the law does not excuse ignorance of the statutes, but the defendant must know that the act in question was not a right thing upon general grounds.

There are some few persons, however, who apparently understand the nature and quality of an act, and know that it is wrong, yet who are so impelled because of stress of disease that they are unable to refrain from acts which they know are wrong; in other words, they are so dominated by imperative ideas as not to be free agents. It is probable, however, in such cases, that a close investigation would reveal that the offender was not cognizant of the real quality of the act.

The plea of insanity as a defence for crime has encountered popular opposition. When the question of insanity has been tried, juries, in some few instances, actuated by sympathy, have accepted the plea as an excuse for the exercise of leniency, and have returned verdicts which seemed miscarriages of justice, and have thus brought this plea into public disfavor. In New York State a verdict of acquittal upon the ground of insanity, if the disease still continues and the jury deem the defendant dangerous to be at large, must be accompanied by a special verdict to that effect, and the person thereupon is committed to a lunatic asylum. Emotional and temporary forms of insanity are not received by either courts or jurors with the credence they were once accorded, nor are they generally recognized by the medical profession.

The history of the law, in relation to responsibility, shows a gradual development; the early test was that a person must be deranged to such a degree as not to know more than a wild beast. The rules of the Macnaughton case, as formulated in the answers of the English judges to the House of Lords in 1843, state that to establish the defence of insanity it must be proved that the defendant did not know the nature and quality of his act, or that his act was wrong. This marked a great step in advance, and formed the basis of the law in criminal responsibility for more than half a century. More recently some courts have ruled that a person should not be held legally responsible if his act was a direct result or product of his mental disease.

The usual procedure, when a person is found to be insane while in confinement awaiting trial upon a criminal charge, is for the court, either of its own motion or upon the request of the district attorney, to suspend criminal proceedings, and to appoint a commission to pass upon the mental condition of the prisoner. If found to be deranged, it is ordered that he be committed to an insane asylum, there to be held until recovered, and then to be remanded to the custody of the court, and the trial resumed. In some instances, when insanity is made a defence, the question is tried and testimony upon the subject taken in open court.

The mental state of all prisoners awaiting trial should be a subject of more careful scrutiny than at present, as many insane recidivists and dangerous lunatics, whose true condition is not recognized, are undoubtedly sent to prison for short terms and then released, whereas they should be permanently confined in asylums for the criminal insane.

Commitment of the Insane by Civil Process.—The statutes of the various States differ as to methods of commitment of the insane, but as a rule an order of court based upon a medical certificate is required before a person can be deprived of his liberty. The testimony of at least one physician is necessary as to the mental condition of a patient; oftener, the medical certificate of lunacy must be signed by two respectable practitioners, legally qualified, who are required to have had at least three years' experience in the practice of medicine, and to be graduates of some reputable medical college. The physicians must examine the case either upon the day the certificate is made or within a short period of days immediately prior thereto, as may be indicated by the statute of the State in which the patient resides. In many States a judicial hearing may be given, in addition to the medical certificate, provided it is deemed necessary by the court. When committed, the patient is taken to the hospital at once, as the order of the court remains valid only for a few days. The whole period covered by the legal proceedings is brief, under the assumption that a patient may recover his reason should the time allowed to elapse be prolonged. The error of incarcerating a sane man is thus avoided. In some instances the law provides for the summary and prompt commitment, as well as temporary detention, of lunatics who may be violently or dangerously insane, without the formality of the usual warrant.

Another procedure is to provide a commission, consisting usually of three members, whose duty it is to take cognizance of all cases of alleged insanity brought before them and to issue warrants of commitment to insane hospitals after compliance with certain forms of judicial proceedings prescribed by statute. The right of personal liberty is so jealously guarded that some States have provided a trial by jury in all cases of insanity. Where such a practice prevails the sheriff is directed to bring the afflicted person before the court and a jury is empanelled, and the trial proceeds as in civil and criminal cases, with counsel privileged to appear upon each side. This course has not been generally adopted.

In addition to judicial commitments, provision is made by law whereby insane patients of their own volition may enter a lunatic asylum and remain as voluntary patients. Such inmates, however, cannot be forcibly detained, but the doors must be opened to them whenever they request their freedom.

The intervention of the habeas corpus is available, of course, for any person committed to a lunatic asylum, and upon the return of such a writ the merits of the whole case may be reviewed by the courts and the rights of any individual who considers himself aggrieved may be finally adjudicated. Furthermore, most States provide for the greatest latitude in the way of correspondence, both as to the mailing of letters as well as to their receipt. In some States no censorship whatever is permitted upon the part of the hospital authorities, and the postal privileges of the inmate are as unrestricted as those of any other individual.

In examining a patient as to his sanity prescribed forms are usually furnished, printed in accordance with the statute. Medical men, in making an affidavit in a case of insanity and in giving the grounds of their opinion, should be guided as far as possible by the evidence of their own personal observations, and describe the patient's general appearance, what the patient said, and what he did; that is, describe his words and acts. It is allowable to note what facts were communicated to the observer by others. It is well also to examine the patient alone, free from all restraint and influence of others. It is not enough to state that the patient is insane, but the reasons for such a finding must be given with sufficient fulness to enable the court to satisfy itself as to the soundness of the opinion.

While many safeguards surround the commitment of the insane, not much formality attends their discharge. In most cases simply the certificate of the medical superintendent that the patient has recovered is sufficient to permit him to go at large. Many persons who fall short of recovery are delivered into the hands of relatives and friends, who are able to give satisfactory evidence of a willingness and ability to care for and maintain the patient in safe custody and without further public charge. Persons cannot be so discharged, however, while being held upon criminal charges, as they are answerable to the court, and upon recovery must be returned at the hands of the sheriff to the custody of the proper authorities to be disposed of according to law.

Appointment of Committees of Persons and Estates.—Very many persons who are neither criminals nor dangerous to themselves or others are yet in need of supervision, and for such the courts make provision. Such supervision may embrace either the person or property or both. It is often necessary to conserve funds which cannot be properly administered by the patient and which are being squandered and dissipated. The purpose of the law is to furnish protection to the interests of the lunatic in much the same way as it guards the interests of infants and minor children.

The duty devolving upon the committee of the person (who is usually a near relative or friend or some one interested in the estate) is to provide comfort and care. He need not personally attend to this, but may place the lunatic in custody of an agent or even in an asylum; but he is bound to look after his interests and to see that he receives proper treatment, and for this he is responsible. The jurisdiction of the court extends to the care and custody of persons incompetent to manage themselves or their own affairs. Such incompetency does not include simple weakness of mind unless it is so great as to constitute disability, nor does it embrace mere lack of business acumen or experience. One of the purposes for which a committee is appointed is that of maintaining actions at law, which may be done by the committee in the name of the lunatic, thus giving a legal standing to acts which otherwise, by reason of the insane person's incapacity, might be declared void. The action of the committee, however, in order to be of authority must be approved and affirmed by the court. The committee of the person or of the estate may be discharged by an order of court whenever it is proved that the lunatic has become competent to manage his own affairs. He is thereupon restored to his full rights both as to his person and property.

Contracts and Partnerships.—Contracts with lunatics are often sought to be annulled by both parties. The sane party sometimes seeks to be relieved from loss or damage upon the ground that the person with whom he contracted was deranged; and on the other hand the insane party, when he finds it to his interests so to do, endeavors to avoid responsibility upon the ground that at the time the contract was made he was incompetent. There are three things usually to be considered in adjudging the validity of such transactions: first, the mental condition of the party alleged to be insane; second, was such insanity evident to the other contracting party? and third, the nature of the contract itself: was it a fair instrument in its terms or was it of a fraudulent nature?

In some cases, in which the person is admitted to be insane and the fact is generally known, simple contracts or agreements have been made whereby the lunatic has been supplied with the necessaries of life, the cost of which are a valid claim to be paid by him or are a claim upon his estate. Checks and drafts may be indorsed by lunatics who have been legally declared insane and who are in an asylum, and even deeds have been upheld—though rarely—when executed under like circumstances. When such acts are questioned, however, the burden of proof to sustain them is often great. It is sometimes required, before legal papers can be executed by an asylum inmate, that an order of a court must be obtained permitting his signature, which order must show that the judge granting it had notice of the fact that the person whose signature is sought was, at the time, an inmate of a lunatic asylum. A man who has once been insane and judicially declared a lunatic may recover his mental strength and afterward resume his civil obligations and discharge his business affairs with full responsibility. This recovery is always a matter of opinion, however; an opinion which is not always fully concurred in by everybody who knows him. Should occasion arise to question his acts, his insanity may become a matter of proof. To invalidate an act, therefore, it is not sufficient to say that a man has been adjudged insane, or is insane, or is even an inmate of a hospital for the insane. If the allegation is made, it may or may not be successfully rebutted by evidence upon trial. A lunatic is competent to act until a committee has been appointed; but in the absence of such appointment, if he subsequently wishes on his own behalf to annul a contract, it must as a general rule be shown that he, as the contracting party alleged to be insane, was so bereft of reason as to be incapable of understanding, and that the other party was aware of such condition.

A sale, however, to a lunatic may be set aside in equity when the lunacy existed at the time of the sale, even though the sane party was not aware of it, excepting when the lunatic profits by it and the transaction was in good faith, and matters cannot be reduced to *statu quo*. A lunatic who borrows money and has the benefit of it, providing the lender acted in good faith and without knowledge of the borrower's insanity, is liable for its repayment. So that a deed or note executed for such a debt has been held valid, even though it may transpire

that the maker was insane at the time the instrument was executed. Notes given and mortgages assumed by men who were subsequently shown presumptively to have been insane have been held valid wherein the insanity was not sufficiently progressed as to have deprived the patient of the power to contract and where it was shown that there was not sufficient mental disturbance to lead the other party to make inquiry thereto.

The existence of insanity in itself does not dissolve a partnership, but only gives ground for an action to dissolve if the other members of the firm so desire. The court may refuse to grant an application for dissolution upon the ground that the affliction is but temporary. Evidence must be brought to show that the deranged partner is so incapacitated as to be incapable of fulfilling his part of the contract and that his malady will be permanent. As a matter of fact, partnerships are often continued for years where one of the active or silent members of the firm has become insane.

Marriage and Divorce.—Marriage is a civil contract, and to enter upon it each party must understand the nature of the act and its obligations, and be at the time a free agent and not influenced thereto by fear or duress. It is not sufficient that the relation of husband and wife be understood, but there must be freedom from coercion. Plans are made at times by designing men or women of unscrupulous morals to decoy the mentally weak into alliances of wedlock for the purpose of obtaining possession of property rights. If a person knows the nature of the relation which he has assumed and enters upon it willingly, the existence of mere weakness of mind, or even insanity, is not sufficient to set aside the marriage. The sane party may have reasonable ground for an action to annul a marriage when deception was employed and concealment of the true mental condition practised, basing his petition upon the ground of fraud in that he had no notice of the patient's physical infirmity and mental aberration prior to marriage. The existence of confirmed epilepsy before marriage and continuing thereafter may be cited as an example. Such an allegation, however, would not be of effect if the parties continued to live together in marital relationship after the facts were discovered. Insanity developing after marriage is, as a rule, not a valid ground for divorce. Some codes provide, however, that continuing and incurable insanity after a period of years becomes a legal cause for divorce. An insane person entangled by a designing adventuress may upon recovery bring an action to avoid such marriage provided he did not cohabit freely after such recovery. Relatives may bring action to annul the marriage of a lunatic or idiot.

Undue Influence.—Closely entering into the consideration of every act of the insane, such as marriage, the making of wills, contracts, the bestowal of gifts, is the question of undue influence. Such an inquiry even may be raised concerning the acts of the sane, as undue influence may be of such a degree as to amount to actual compulsion through physical fear. The test should be applied here as elsewhere. Did the person know the nature and quality of the act and the consequence to himself and others, and was he a free agent at the time? Gifts are sometimes made by the mentally enfeebled to those who are friendly acquaintances or their custodians, and made under such circumstances as to lead to the belief that the donor was not untrammeled but was subject to pressure by promises or threats, or coerced by fear of unpleasant consequences of a refusal to make the gift. Valuable bonds, stocks, and mortgages have been thus bestowed upon others, and in some instances such assignments have been declared void. Undue influence cannot be presumed; yet, because it may be alleged in an action at law to set aside a transfer, it is well to have such transactions carried on in the presence of others and not made when only the parties interested are present. Even though the donor was actuated by kindly motives and a long-fixed intent to reward faithful service, yet it is desirable that outside and disinterested persons be present as witnesses of the free exercise of will on the part of the giver and of possession by the latter of due knowledge of the purpose and meaning of the gift.

Testamentary Capacity.—It is difficult to set up a standard of sanity or mental capacity. As insane persons are capable under certain conditions of executing valid contracts, so in the devising of property they are competent to make wills. It must be shown, in order to sustain an instrument, that the testator had a knowledge of his estate and of the property to be devised. He must also possess sufficient memory to recall those who naturally would be dependent upon him and he must be free from the undue influence of others. The domination of insane delusions must not be sufficient to control his acts. The fact that a will was made in a period during which the testator was known to have been insane raises a presumption against its validity, but it may be shown by evidence that the testator was competent at the time the will was made; that his delusions and mental disturbance were such as not to influence him in the making of a sound disposition of his property. As an aid to this end, the will itself may be an instrument of such a nature as to show upon its face that the apportionment was a sensible, rational, and equitable division of property. It would be of importance if the document was in the deceased's own handwriting. All the circumstances attending its execution are of value. On the other hand, when the testator manifests a decided aversion to some member of his family, and when an apparent malignancy or deep and seemingly uncalled-for dislike is accentuated by the provisions of the will, or when a man foolishly devises his estate to strangers, and perhaps to a profligate, to the exclusion of his own family, a strong presumption of doubt would arise, yet the mere fact that such a disposition is made does not invalidate a will. The question of undue influence must be proven, or the existence of delusions which governed his act or such an extent of mental disease must be shown as to interfere with the disposing powers of his mind. Wills have been admitted to probate and proven where the testators have at the time the wills were made been inmates of lunatic asylums. The occurrence of insanity subsequent to the making of a will does not invalidate the will, though, if its provisions be of an unusual character, the fact of the existence of insanity at the time it was drawn may be made a subject of inquiry. The supervening insanity, especially if it should occur soon after, taken in connection with any eccentricity of the person or peculiar nature of the will, raises a presumption of doubt only. The law relating to wills is not uniform, neither as to present usage and practice, nor has it been uniform in the past. It was formerly held that the mere existence of insanity rendered a person incompetent to draw a will. Modern authorities, however, admit testamentary capacity, even though delusions exist, providing they have no bearing upon the provisions of the will and do not influence the testator therein. Some degree of mental unsoundness may be present, yet if a person possesses an understanding of the nature of the property to be devised and the person to be benefited, and of their relation to each other and to him, sufficient capacity exists for the making of a will. Such knowledge need be but elementary. Even though the mind may have been actively disturbed by disease, the proven existence of a lucid interval at the time the instrument was drawn is sufficient to validate the terms of the will.

Competency and Credibility of the Insane as Witnesses.—The insane are capable of observation and of giving rational accounts of what they have seen and heard. It is not usual, however, for them to be capable of so doing, particularly as to acts which directly or indirectly concern themselves. Lunatics are apt to be biased concerning matters which relate to their own personality. Egoism is most prominently intensified in mental derangement. Their testimony, however, has been admitted in the English courts and in both the Federal and State courts of this country. Each case, however, must be examined upon its merits. It must be first determined that the lunatic has sufficient intellect to understand the nature and solemnity of an oath. This and his general mental

condition must be the subject of a judicial examination before his testimony becomes admissible. The character and extent of his delusions should be shown, the amount of mental impairment which he has sustained, his general reputation for veracity, and whether his observations are prejudiced by his mental disease. Persons who have intellect enough to be thought competent as witnesses often believe themselves sane and wrongfully detained and are therefore inimical to attendants and to hospital authorities. Their statements are colored by personal grievances and often by ill-will. The moral faculties are also often weakened to a considerable extent and the sense of ethics is blunted or lost, so that a searching examination should be made before admitting the evidence of insane witnesses. So many uncertainties, moreover, surround the giving of such testimony that it should seldom be received, standing alone, but should be regarded as only corroborative of testimony given by others. In other words, a lunatic's competency should be a matter of proof and accepted with caution. Formerly all such testimony was excluded. The statements as to immoral acts made by hysterical and nervous women verging upon insanity should be regarded with hesitancy; otherwise wrong may be done to the character of upright members of the community. Judgment in all such cases should be suspended until their testimony is strengthened by other and more reliable evidence.

The Supreme Court of the United States has ruled upon the subject as follows: "The general rule, therefore, is that a lunatic or a person affected with insanity is admissible as a witness if he have sufficient understanding to apprehend the obligation of an oath and to be capable of giving a correct account of the matters which he has seen or heard in reference to the questions at issue; and whether he have that understanding is a question to be determined by the court upon examination of the party himself and any competent witnesses who can speak to the nature and extent of his insanity."

Intoxications.—The various acute intoxications produced by alcohol, morphine, cocaine, and other drugs do not properly come within the scope of insanity, but continued indulgence produces a chronic mental condition which is a form of mental disease, progressive in its character, and often permanent. Mere drunkenness is no excuse for crime; in fact it was once held that, where it was voluntary, it aggravated the offence. At the present day, when a criminal act is committed through drunkenness, the degree of guilt may be modified as showing an absence of intent or premeditation. A contract may be disclaimed and voidable on the ground of intoxication at the time of its execution. Alcohol, opiates, and various drugs may invalidate documentary acts if the subscriber was so under their influence as to be incapable of appreciating the nature and quality of his act; but the assumption must be sustained by proof. The instrument itself may not be void, but it is voidable upon an action at law to set it aside. Voluntary acts of intoxication do not absolve from responsibility, but if the drug is administered as an overdose by a physician or by accident or in a weak physical condition from disease it does so relieve.

There are conditions, however, not acute, but which result from chronic alcoholism and chronic morphinism, wherein there is a mental derangement of a more or less permanent nature, often progressive, and at times ending in terminal dementia or some fixed condition of insanity. Hallucinations of sight and hearing are common, often attended with delusions of persecution. Sometimes symptoms are present resembling very much general paresis. The patient's mental state and consequent responsibility become in such cases a matter for the jury, and the test applied is the general one used in mental disease.

Modified Responsibility.—Deaf-mutes, idiots, and imbeciles are not insane, but their responsibility is variable. An act committed by an idiot or imbecile is not a crime. In such cases, however, the actual condition must be made a matter of proof. An honest difference of opinion might possibly arise in a given instance as to whether a weak-minded person should be sent to an institution for the feeble-minded, to an industrial school, to prison, or to a hospital for the insane. Uneducated deaf-mutes are occasionally accused of crime. Such a person, not being able to read and write or to talk by means of the alphabet of the fingers or by signs, is incapable of communicating with counsel or of participating in his own defence. To all intents he is in a state of nature and occupies the status of an idiot. Such persons have been adjudged irresponsible and committed to insane asylums. On the other hand, responsibility may be proved by showing the accused to have had education in special schools; that he is able to read and write; that he can converse by the sign language; that his moral sense has been developed; that he has a knowledge of right and wrong, and consequently that he has attained to a measure of understanding which renders him responsible before the law. The real status of deaf-mutes, therefore, must be determined by testimony similar to that required in cases of insanity. Their mental states, dependent upon their deprivation, being so various, each case must be determined upon its merits when questions arise concerning criminal responsibility, marriages, contracts, and wills. A deaf-mute should always have the benefit of a competent interpreter.

Epilepsy.—This condition is often attended with maniacal paroxysms. On account of the violence accompanying such outbursts, acts of homicide are often committed. From our own observation, about forty per cent. of the crimes committed by epileptics are of the nature of assault or murder. If we add rape we should increase this percentage to almost fifty, so that very nearly half of the crimes committed by epileptics are acts of violence against the person. If we consider other classes of insanity, however, in connection with epilepsy we find that the latter is not a large causative factor, as this form of disease is responsible for less than five per cent. of all murders committed by those mentally deranged. Acts of violence by epileptics are usually committed in states of fury followed by convulsive attacks of which the patient has no memory. Sometimes, though rarely, states of excitement occur unattended by convulsions but followed by lapse of memory. Dementia as a rule supervenes after long-continued epilepsy. The measure of responsibility in all such cases is the universal test which applies to all states of mental derangement.

Plea of Insanity.—The plea of insanity as a defence for crime is not always received with public favor. It is apt to be regarded as a subterfuge and an excuse for leniency, whereas if it prevails it involves, in most cases, confinement for a period of longer average duration than a sentence to a penal institution would entail. Such a plea, owing to popular prejudice, is not always accepted by the jury, and many dangerous paranoiacs are convicted and committed to prison only to be liberated at the end of brief terms to commit fresh crimes. The mental condition of prisoners should be subject to careful scrutiny, and if found to be insane they should be sent to special lunatic asylums to remain until recovery is assured. Many recidivists would thus be placed in permanent custody and our prisons and reformatories be permanently relieved of a large proportion of habitual criminals and of many dangerously insane convicts. Fortunately, the laws of several States direct the transfer to asylums for the insane of all patients whose insanity becomes evident while undergoing sentence, and permit of their detention until recovery or death. Where such a practice prevails, persons convicted of manslaughter, assault to kill, and other heinous offences, whose felonious acts are the product of mental derangement, are segregated apart from sane convicts and detained during the existence of their disease.

As a rule the types of insanity existing among those who commit criminal acts are characterized by degeneracy, are fixed in their nature, and, usually, irremediable. Self-admiration is so strong among offenders of this class that they resent any impugnment of their mental condition, but a verdict of chronic and confirmed insanity

would be justified in many instances as a measure calculated to insure confinement for life. Such a course is not only humiliating but is a severe blow to their pride and arrogance, which leads them to crave notoriety as heroes and martyrs. Many so-called anarchists are really unbalanced persons whose crimes fall short of murder, but who nevertheless should be branded as insane and degenerate and who should permanently pass out of sight and mind behind the closed doors of lunatic asylums.

Henry E. Allison.

X. INSANITY, CONFUSIONAL.—The term "confusional insanity" is one used in the symptomatological classification of mental diseases and is meant to include cases possessing a definite group of clinical symptoms. It must be understood at the outset that there has been the greatest confusion in the classification of mental diseases. This is due to several causes, not the least of which is the persistent adherence of many writers and physicians to the etiological classification. When we remember that the same exciting causes apparently act in producing widely varying clinical forms of disease, and when, on the other hand, we see the same clinical disease following upon a great variety of causes, the reason for this confusion is apparent. Unfortunately, hardly any two writers use the very same scheme of classification, and our hospital reports reveal the fact that there is no uniform use of the terms defining mental disease in vogue to-day.

DEFINITION.—Under the term confusional insanity we include those cases in which there are abundant hallucinations and consequent delusions with usually considerable mental confusion or delirium. When we consult the various text-books, we find such clinical pictures described under various terms which may be arranged as follows:

I. *Primary.* — Acute confusional, primary confusional, or acute hallucinatory confusional insanity; acute primary dementia (agitated or stuporous); delirium (acute or grave); typhomania; delirium of collapse; acute delirious mania.

II. *Secondary.*—Infectious insanity; febrile psychoses immediately following fevers, as influenza, typhoid, malaria, erysipelas, rheumatic fever; post-partum insanity; traumatic insanity; acute toxic insanity (alcoholic, etc.). Heretofore many authorities who did not employ the term confusional insanity have placed these cases under either mania or melancholia—terms decidedly overburdened in the past.

ETIOLOGY.—While I have grouped cases of confusional insanity under two etiological heads, namely, primary and secondary, I recognize the fact that the subdivision is artificial, and when our knowledge of the causes of insanity becomes complete, the "primary" cases will diminish in number and all cases will possibly be found to have a common cause.

In this type of insanity, as in other acute forms, we may expect to find a dual causation, such as a toxalbumen in the blood acting upon a predisposed, unstable, nervous system. The writer believes that this twofold etiology is all but universal in mental diseases. Medical practitioners see an endless variety of idiosyncrasies or susceptibilities among their patients to drugs or common articles of food.

It is not unreasonable to expect that there is an equally variable susceptibility to the various chemical substances which may be found in the blood, whether normal products of metabolism or the toxalbumens resulting from infectious diseases. The well-recognized fact that in the majority of insane there is a history of neurotic taint in others of the family strongly supports this view. Given then an unstable nervous system in a neurotic individual or a degenerate and let him meet with any of the many accidents which may tend to lower his vitality or be attacked with an infectious disease, we have a right to expect profound nervous disturbance. If the dose of the poison be unusually large, either from a sudden absorption by the circulation or from defective elimination, we may expect serious mental symptoms. On the other hand, the more unstable the nervous system, or the more susceptible, the more quickly may we expect such symptoms from a relatively small quantity of the excitant poison. As this factor is incapable of measurement and is always uncertain it interferes with the making of a definite prognosis. Experience shows that the history of numerous cases of mental or nervous disease in the family does not warrant a bad prognosis in a case of confusional insanity. Such a family history may indicate merely an unusual instability or susceptibility to a trivial exciting cause and recovery may be rapid and complete.

CLINICAL HISTORY.—The onset of symptoms is usually rapid. They may occur with startling abruptness. The prodromal symptoms are restlessness, insomnia, or sleep is broken by disturbing dreams, irritability, headache, and some mental confusion. In women we often see some hysterical symptoms. This evidence of a loss of self-control must not be slightingly considered, as it may be the forerunner of serious mental disturbance. One of the first symptoms to be noticed is hallucinations of one or more of the senses, usually of more than one. Hallucinations of hearing and sight are especially common. Consequent upon the hallucinations are delusions. The patient hears voices in the room or the wall, or overhead, or the next room, which tell of distressing things about to happen—that the patient is to be burned or killed, or that his soul is lost, or his children are to be tortured, or his loved ones ruined; that his friends are to prove false, he is to be financially ruined, etc., etc., or he hears pistol shots or the noise of fire engines. Hallucinations of sight of the same nature add to his distress. Strange forms—robbers, monsters, officers of the law, forms of the departed, the figure of God, the Virgin, or the dead—appear before him. A rapid shifting of these hallucinations gives rise to various delusions and sudden acts of violence and attempts to escape on the part of the patient. Suicidal and homicidal attempts are not uncommon during this delirious condition. Friends and members of the family are not recognized; the physician is taken for an enemy or the Evil One. The hallucinations and delusions are not always persecutory, although more commonly so. They may be of a hypochondriacal nature. The patient may believe he has no stomach or he is dead.

Or the hallucinations may be of a religious or erotic character. A woman believes she has been assaulted and outraged, or she has seen the Saviour and He is to make her His bride. Hallucinations of all the senses may be looked for, and we frequently find the patients complaining that poison or filth has been put in their food or foul gases are injected in their room.

The delusions of these cases are as a rule transient and change with the hallucinations. They are not fixed as in the cases of primary delusional insanity (paranoia). The delusions are more freely talked of soon after the onset of the disease and gradually fade, while in primary delusional insanity there is an evolution of the primary or chief delusion, and it is talked about more and more as the disease progresses.

Some patients, however, will not express their delusions. We can observe merely a suspicious attitude and we can only infer the presence of hallucinations and delusions from the patient's behavior, which expresses fear, terror, a capriciousness or change in conduct toward those about them. Such a case may first attract attention by jumping from a window, and it is not always possible to decide at once whether this was an attempt at suicide or a frantic effort to escape from some imagined harm.

There is almost always seen some confusion of mind. There is incoherence of ideas, a failure to recognize friends or surroundings (disoriented). Mistakes of identity are very common. This essential symptom may be of all degrees from a simple haziness of comprehension, a misunderstanding resulting from the hallucinations, to complete delirium with no memory of the illness remaining upon recovery. There is, as a rule, a partial memory

of the events of the illness upon recovery. Patients often remember their coming to a hospital and say that for some weeks it was a blank, or there may be almost a complete memory of the events connected with the period of alienation. Occasionally the delusions may persist after the hallucinations have disappeared and the patients have in other respects recovered. Such cases often are very troublesome, as they repeat stories of abuse during their illness after they have apparently recovered, and even after they are able to return to their homes they blame their friends or physicians for an improper commitment. They retain a vivid recollection of the necessary restraint exercised by nurses or friends and persistently refuse to see that such methods were needful or humane. As a rule, however, the delusions fade with returning health, and a reasonable attitude is taken.

The progress toward recovery in curable cases is not always uniform. There may be several relapses to the confused state during convalescence; the saner periods ("lucid intervals") may be short, or the periods of confusion, usually two or three, may be separated by longer intervals of comparative sanity. Occasionally, there may be a daily alternation of sane and insane periods extending over a period of weeks. This is sometimes so marked as to suggest malarial infection.

The course of this disease in recoverable cases varies from a few weeks to a year. It is seldom less than two months and is often more than six. While the majority of patients recover, in the more severe cases death ensues from exhaustion. In the class of cases described as *acute delirium* death is almost certain. In other cases a chronic insanity follows—it may be a chronic deluded condition resembling paranoia or there may be a tendency to dementia.

This disease is chiefly one of middle life, occurring between the ages of twenty-five and fifty. But no fixed age limit can be set as it is evident that the conditions of an unstable nervous system and the introduction of noxious substances into the circulation may occur at any age. This condition may be seen during old age, though it is not common. It is noticeable that while children are especially subject to infectious diseases, the occurrence of this type of insanity in children is very rare. Yet children are especially liable to a brief febrile delirium in the course of infectious diseases.

While I have attempted to give a brief and general description of this malady, it must be borne in mind that individual cases show a great variety of symptoms or a predominance of one group over others, and it is perhaps true that no two cases present exactly the same clinical picture.

In some of the younger cases, occurring soon after puberty, we are apt to find a stuporous condition, which, for a time, may be so prominent as to mask or suppress the essential hallucinations or delusions. This class of cases (*acute primary dementia, curable*) exhibits a profound stupor or passivity. There is marked cerebral anæmia, and evidence of a sluggish circulation. The patient lacks the initiative and will make no effort to eat until food is placed in his mouth, and he may even not swallow then. He neglects the calls of nature and will lie passively all day long. The cataleptic condition may ensue. There are dilatation of the pupils, diminished reflexes, and cold surface.

There is no resistance as is seen in melancholia. This condition may result from a mental shock or from any physical cause producing exhaustion or anæmia, such as parturition or febrile disturbance or trauma.

The stuporous condition disappears and more active symptoms supervene and we see for a time the hallucinations, delusions, and excitement as already described. We may see one or more relapses into the stuporous condition before recovery takes place.

Acute or *grave delirium* or *typhomania* is, fortunately, a rare condition and may fairly be considered to be an extreme type of this affection. There is always an elevation of temperature which may be due to the infection of pneumonia, tuberculosis, measles, etc. It is the most severe form of maniacal delirium seen. It may come on very suddenly, so that if the patient be seized while among strangers it may never be possible to identify him. Death is the rule after a brief and severe illness, averaging about ten days, the delirium becoming muttering and later giving place to coma. It is probable that this grave form will soon be classed with the infectious insanities, and it may be that it will be found to follow infection of the cocci.

Insanity is a frequent complication of the infectious diseases both during and after the febrile movement. It is seen in variola, typhoid fever, scarlet fever, measles, pneumonia, cholera, erysipelas, rheumatic fever, influenza, diphtheria, multiple neuritis, phthisis, or any of the inflammatory processes.

In the majority of cases the symptoms are those of confusional insanity.

The delirium may precede the rise of temperature (*initial delirium*), but more commonly occurs during the height of the febrile disturbance. Such a delirium may occur in those who possess a normal brain stability. In such cases there is a serious poisoning from the toxalbumens and an impoverishment of the brain cells from the circulatory and nutritive disturbance. But in those possessing marked nervous instability delirium may accompany a low temperature. Febrile deliria, though characterized by the hallucinations, delusion, and great confusion seen in confusional insanity, are by common consent not deemed a true insanity, although psychologically and clinically they may not be distinguished from confusional insanity.

If with the subsidence of the febrile movement the delirium persists, or at this time makes its appearance, we have clinically another variety of the psychosis which is described as *post-febrile delirium* or *insanity*.

In these cases the mental symptoms are not so evidently the result of the febrile condition. While it is true that the toxins are still a factor, the exhaustion of the brain cells is also a potent one. Under these conditions one may see a short delirium with great excitement and extravagant or distressing delusions where the patient takes no notice of surroundings, and, if the exhaustion is not fatal, recovery taking place within a few weeks (*collapse delirium*). Or there may be a less furious mental disturbance running the slower course of confusional insanity as described.

The complication of the puerperal condition with any form of mental disease, whether mania, melancholia, hebephrenia, paranoia, or confusional insanity, is loosely spoken of as puerperal insanity. The last mentioned is the form of insanity described in the books as the type of puerperal insanity, or mania, and is more precisely described as *post-partum insanity*.

Much has been written upon this distressing condition and its occurrence is very alarming and naturally causes the greatest anxiety for the family as well as for the patient. Many of these cases are simply an infectious insanity and run a short course. Since the general use of antiseptics in midwifery this trouble is undoubtedly less frequent. This complication is undeniably seen when the parturition has been free from a considerable rise of temperature. It is highly probable that the exciting poison is distinct from that which supposedly causes a rise of temperature, and this acting upon a brain impoverished by a diminished blood supply or impaired by months of worry and anxiety (arising from poverty or illegitimacy of the child, *e.g.*), with insomnia, produces mental alienation. The course of the disease is similar to that described, and all the varieties occur.

It is imperative that the child be taken from the mother at the earliest intimation of trouble, both for the child's safety and to relieve the mother from any annoyance. Where there is active delirium and a possibly brief course of trouble, home treatment may be tried, but only with sufficient assistance from nurses to allow constant attention upon the patient. Such care is, as a rule, impossible for financial reasons, or, in densely populated districts, the annoyance to the neighbors is too great to be endured,

and one is driven to resort to unduly radical measures to keep the patient quiet.

Delirium tremens is so generally considered to be a disease entity that its consideration will be found elsewhere. It is clinically to be regarded as a special variety of confusional insanity with a well-known exciting cause and especially characterized by hallucinations of sight and delusions of a distressing character.

Confusional insanity is also the result of poisoning by other toxic substances, as morphine, ether, chloroform, cocaine, etc. The term "toxic insanity" is commonly used to describe acute mental disturbances due to poisoning by these drugs.

Differential Diagnosis.—While the term mania, as often used, includes those cases here described as confusional insanity, it is more accurately used to define a condition of exhilaration or good feeling, with great motor activity and restlessness with an increased flow of ideas, in which hallucinations and delusions may be present, but delirium and confusion are not marked. Mania comes on slowly and begins before the age of thirty years, is apt to recur and is a comparatively rare disease. There is in mania an hereditary predisposition. Melancholia, which is closely allied to mania, begins slowly often after an attack of neurasthenia, is characterized by a primary depression of spirits; the depression is not secondary to distressing delusions, and there are self-depreciatory delusions; orientation is good. It does not tend to follow febrile delirium. As in mania there is a tendency to recur.

In paranoia there are fixed delusions without confusion. Paranoiacs, however, are subject to exacerbations of excitement, which may for a time be mistaken for attacks of confusional insanity. A close study of the case will soon remove all doubt.

There is frequently some difficulty in differentiating the short excitement and semi-delirious conditions seen in cases of general paresis or other organic brain disease. Observation and careful study of these cases will soon reveal evidence of gross brain disease, and the diagnosis may then be established. When the onset of general paresis is sudden and follows a febrile disturbance, as it does not infrequently, a positive diagnosis is impossible at the outset.

Prognosis.—The prognosis is, as a rule, favorable except in the severe cases of the most acute form of delirium in which the exhaustion is so profound as to cause death or in which it may be affected by the complication of a physical trouble.

If there is a fair stability of the nervous system, recovery from the mental symptoms, with the exceptions mentioned, may be looked for. The best index to recovery is an increase in bodily weight, and it is important to keep a weekly weight chart for consultation. The increase in weight is often very rapid, sometimes five pounds a week for several weeks. In women a return of the catamenial flow is an index of restoration of the physical health, and if the mental condition does not improve simultaneously or very soon after the physical improvement, there is reason to fear a terminal dementia or chronic insanity.

Recovery should take place within a year or so, at most, from the appearance of mental symptoms. If there is no decided improvement within fifteen months, the case may be said to have become chronic. The hallucinations with confusion may continue and *chronic confusional insanity* results, which like other acute vesaniæ tends toward a decline of the mental powers with a terminal dementia which is of various degrees.

In a certain proportion of cases the confusion disappears, but the delusions, which are more or less fixed, may persist and we have a chronic delusional insanity with a less rapidly ensuing dementia.

Or the stuporous condition may recur or persist and lead to a chronic dementia. It is assumed that the inherent strength of the neurons is weaker in these cases and they are incapable of restoration.

Treatment.—The place for treatment must be early considered in every instance. If the case is very acute and there is reason to expect a short illness, home treatment, if practical, should be advised. It must be admitted that the fact of commitment to a hospital for the insane does affect the business and social status unfavorably, although this prejudice is often very unjust and unreasonable. Home treatment should not be attempted without the assurance of abundant and competent nursing aid, which is necessarily expensive. In the majority of cases, however, it will be found necessary to resort to treatment in a hospital especially equipped for the care of the insane.

The exhaustion calls for prompt and assiduous measures. Frequent and regular feeding is all-important. It may be that artificial feeding by means of a nasal tube will be required, but it should not be resorted to until all attempts to persuade the patient to take food naturally have failed.

The food should be simple and re-enforced with stimulants, especially alcohol. If feeding and bathing do not induce sleep, hypnotics may have to be used, but their use is to be deprecated unless absolutely necessary. Bromides, trional, or sulfonal should be tried first. Rarely in an acute delirium a few doses of morphine with atropine subcutaneously, may be necessary to induce a brief rest. This should not be used repeatedly, but be followed by the hypnotics. Frequent feeding with liquid food, with small amounts of chopped meats and repeated small doses of alcohol will often induce a natural sleep, especially if supplemented by warm baths or sponging. Attention should be paid to the rapid elimination of poisonous products by aiding the bowels, kidneys, and skin to throw off their excretions.

At first rest in bed is essential. To accomplish this, forced detention in bed often becomes necessary. This may be done by the nurses holding the patient, but preferably by mechanical restraint, as a sheet, or more rarely by some bed harness.

If the patient must be held for any considerable time by others, there is a liability to increased exertion and resentment on the part of the patient, who is more apt to yield to the inevitable of mechanical restraint. The excitement and fear are increased when the patient is held in the grasp of others.

After the stage of exhaustion is past and food is taken well, tonics, as iron, strychnine, and phosphates, are called for. Bodily weight should be watched as it is the best indication of improvement. A quiet environment away from the presence of over-zealous and well-meaning friends does much to promote recovery. Strangers can usually do better for a patient who is not in an unconscious state than can members of the family.

Edward B. Lane.

XI. INSANITY: ALCOHOLIC AND DRUG INTOXICATION AND HABITUATION. I. Alcoholism.—*Causes.*—The causes of drinking are infinitely varied and intimately bound up in the heart of man—at once an expression of his strength and his weakness, his successes and his failures. The habit is usually begun in early life, before the age of thirty,[1] and in some cases, fortunately, is renounced at the alcoholic climacteric[2]—from forty to sixty-five. Those who yield to its seductions and become its slaves have usually a neuropathic constitution, either inherited or acquired, and it is in this class of persons that alcohol works its worst ravages. Either as the result of inherited defect or the effects of severe mental or physical stress, such as illness (typhoid, syphilis, la grippe), injury (trauma capitis, sunstroke, shock), worry (domestic infelicity, financial reverses), the physiological crises (puberty, menstruation, pregnancy, lactation, etc.), the individual feels an organic craving for assistance in the struggle for existence, and, yielding to alcohol, is wooed by the blissful euphoria it brings into repeated and finally confirmed indulgence. Some are quickly destroyed by the poison (*alcoholic selection*[3]), others resist its ravages for a long time only to yield in the decrepitude of old age or as the result of accidental conditions. Although standing, as

it does, next to heredity as a cause of insanity (eighteen to twenty per cent. in males[4]), we still find it not infrequently as an effect. Indulgence in alcohol is especially apt to be an early symptom in general paresis and often is prominently in evidence in the recurring maniacal attacks of circular insanity.

Symptoms.—The immediate effects of alcohol taken to excess are exhibited in the phenomena of *drunkenness.* In this condition there is a preliminary period of stimulation of short duration, during which there is slight increase in both mental and physical power. This increase, however, is often more apparent than real[5] and is followed by symptoms of abolition of function which affect the nerve centres from above downward,[6] the highest centres being paralyzed first, the lowest last.[7] Thus in the early stages of intoxication there is a loss of the sense of propriety, the moral tone is degraded, the faculty of attention lessened, and capacity for mental work decreased. This condition becomes worse and is followed by lack of muscular co-ordination, manifesting itself first in the hands and facial muscles, and the muscles controlling articulation, the speech becomes thick, the gait unsteady. Disturbances of sensation appear, such as tinnitus aurium, diplopia, and the senses of touch and pain are lessened. If the paralyzing action of the alcohol is still further increased coma results, which may prove fatal.

The mental condition during intoxication is usually one of boisterous exaltation—*exalted type*[8]; but certain individuals are affected in an opposite way and are downcast and lachrymose in their cups—*depressed type.*[8] Among certain predisposed neuropathic individuals (*déséquilibres*), however, alcohol does not produce these typical results but gives rise to conditions of *pathological drunkenness.*[9] In this condition hallucinations and delusions dominate the field of consciousness, the depression may be so profound as to result in suicide, or, on the other hand, the maniacal form may issue in a wild destructive homicidal frenzy. Muscular co-ordination in these cases may be remarkably well preserved, and such persons are said to get drunk in their heads and not in their legs. In this category belongs also the *convulsive drunkenness of Percy.*

Once confirmed in the use of alcohol the individual starts on the downward path toward complete mental and physical decay, in reality a premature senility[10] of mind and body. The effects of the poison are exhibited in every organ of the body, more particularly the central nervous organs, stomach, pancreas, liver, kidneys, and blood-vessels, and give rise to characteristic symptoms as a result, the most prominent of which are tremor, gastric catarrh, arteriosclerosis, albuminuria, and progressive mental enfeeblement.

The effects on the nervous system are shown in disturbances of sensation, motion, and the intellect. The *sensory* disturbances are paræsthesia (pricking, tingling, formication), hyperæsthesia and hyperalgesia, occurring usually in patches, and anæsthesia also of patchy distribution but sometimes affecting only one side (*the hemianæsthetic form of Magnan*[11]). The sensory disorders of the special senses involve principally the eye and ear, producing illusions and hallucinations, muscæ volitantes, photopsia, amblyopia and amaurosis, diminution of the acuteness of hearing with the production of subjective noises (hissing, ringing, roaring, etc.) due to middle or internal ear disease.

The *motor* disturbances are tremor, spasms and cramps, epileptiform attacks (*alcoholic epilepsy*), general motor enfeeblement with paresis (*alcoholic pseudo-general paresis*).

The *mental* changes are gradual and progressive, the intellect is obtunded, the judgment overthrown, the moral sense blunted, and mendacity appears in its most bizarre forms; delusions may develop, the most characteristic of which is that of marital infidelity and jealousy (*Eifersuchtswahn*) and the patient sinks gradually into a condition of permanent mental enfeeblement (*alcoholic dementia*).

Aside from this gradual mental enfeeblement which occurs as a result of chronic alcoholism, much more pronounced mental symptoms often appear and constitute veritable psychoses. These psychoses are, however, all tinged by the symptoms of mental defect to a greater or less degree.

The most frequent and characteristic disturbance of acute alcoholism is *delirium tremens.* This disorder usually occurs as the result of a prolonged drunken debauch during which the patient has had insufficient food and rest. It may, however, appear as the result of a single excess or in the moderate drinker following a traumatism or the initial symptoms of an acute illness. The disease may appear suddenly, but there is generally a prodromal period during which the patient is nervous, with coated tongue, suffering from anorexia, restlessness, tremulousness, disturbed sleep, and insomnia. This condition rapidly advances with the onset of the attack, the characteristic symptoms of which are rapidly developed. They are tremor, delirium, and albuminuria.

The *tremor* involves more particularly the small muscles of the hand, face, and tongue, but may also affect the entire musculature. It is increased by muscular tension, such as forcibly spreading the fingers apart.

The *delirium* is an acute hallucinatory confusion (*hallucinatorische Verwirrtheit*). The predominating hallucinations are visual and characteristically take on the form of animals (*Thiervisionen*). The patient sees all sorts of horrible creatures, snakes, rats, mice, alligators, etc., which are uniformly in motion. Surrounded by the loathsome creatures, and by horrible grimacing faces, terrified by screams and shrieks (auditory hallucinations), he presents a picture of abject terror. In addition to these symptoms the patient may complain that insects or worms are crawling under his skin (paræsthesia) and mistake spots upon the bed or walls for bugs, mice, etc. (illusions). At the height of his excitement the patient is in constant motion, picking insects from his night-dress, repelling the approach of terrible animals, shrinking from fearful visions, startled by terrifying shrieks, and, in the extreme frenzy of his fright, he may make murderous assaults on those about him, believing them to be his enemies, or more commonly attempt his own life to escape from his horrible surroundings. During all this time the patient is constantly talking, shrieking in fear at times, at others carrying on an incoherent discourse with imaginary persons fragments of which often relate to his former occupation and friends. Physically he is in a condition of acute exhaustion. The pulse is rapid and of low tension, the temperature normal or only slightly elevated (occasionally high, the *febrile delirium tremens of Magnan*), the body bathed in a profuse perspiration and constantly agitated by muscular shocks and tremors.

Albuminuria is found in a considerable proportion of cases, probably considerably over fifty per cent.,[12] during the early stages. At the height of the delirium *leucocytosis* has been found.[13]

Sommer[14] sums up the symptoms of delirium tremens under seven heads: (1) confusion; (2) the numerous sense deceptions, especially in the visual field and particularly the zooscopic; (3) great motor unrest; (4) the tremor of the hands and the shaking of the whole body; (5) albuminuria; (6) a duration of about three and one-half days; (7) termination in a long sleep.

Occasionally one sees cases ushered in by all the typical prodromal symptoms, sweating, atonic dyspepsia, restlessness, tremor, præcordial distress, anxiety, and disturbed sleep which do not proceed to the typical condition of mental confusion with multiform hallucinations. This is the so-called *abortive type*, the *delirium sine delirio* of Döllken.

The disease is of good *prognosis*, terminating in from three to ten days in a long, refreshing sleep. After repeated attacks a residual delusional state is apt to be chronic.

Continued indulgence in alcohol may give rise to various other psychoses much less characteristic of their origin than delirium tremens. Thus we have *acute alcoholic*

mania (*mania a potu*)* and *acute alcoholic melancholia.* Neither presents markedly distinctive features, a fact which separates them from the simple vesanias. They are, however, usually of sudden incidence, equally sudden subsidence, and of short duration. Their diagnosis must depend on the history and the coincidence of the symptoms of chronic alcoholism—viz., arteriosclerosis, albuminuria, tremor, gastritis, fatty heart, hepatic cirrhosis, polyneuritis, paresis, anæsthesias, etc.

The *melancholia* may be very profound, amounting to stupor, and the patient may present marked suicidal tendencies.

The *mania* is apt to be marked by its explosive character, a violent frenzy being initiated by slight causes, during which the patient is extremely dangerous, often destructive and homicidal.

Both varieties tend to present hallucinations, both visual and auditory. Recovery may be complete or followed by signs of permanent mental enfeeblement in the midst of which delusions manifest themselves more or less clearly in accordance with the amount of intellectual reduction.

More characteristic of chronic alcoholism are the delusional psychoses which develop and constitute a *paranoid* state variously designated as *chronic delusional insanity, alcoholic pseudo-paranoia, chronic alcoholic insanity* (symptomatically a form of the *hallucinatorische Wahnsinn* of the Germans).

This psychosis may come on suddenly in a chronic alcoholic as the result of an unusual excess, or it may be of gradual evolution. It is characterized by hallucinations, auditory and visual predominating, with delusions of a persecutory nature in which the sexual element is frequently prominent. Throughout, impaired judgment, poor memory, and general intellectual enfeeblement are prominent factors which prevent the elaborate systematization of the delusions as in paranoia, although a feeble attempt at this is discernible.

Whether of sudden or gradual onset the first symptoms are generally hallucinations with which persecutory delusions are intimately bound up. The patient hears voices making all sorts of inimical remarks, telling him that his children are not his own, calling him an onanist, reviling or threatening him. A voice is sometimes referred to the epigastrium (epigastric voice[15]), and in every way his persecutors annoy him by their malign comments. Visual hallucinations, if they occur, are equally unpleasant. Hallucinations of smell and taste are not infrequent and are, the author believes, to a considerable extent dependent upon morbid conditions of the mucous surfaces in nose, mouth, and pharynx.

The delusions of this state harmonize well with the hallucinations. The patient is persecuted by invisible enemies who inject noxious vapors in his room at night, poison his food, draw off his semen, and produce nocturnal pollutions. He believes his wife unfaithful, and will often complain that she brings men home to the house, and even go so far as to say that she has performed the sexual act with strangers in his presence, showing well the great impairment of judgment.

It must be remembered in this connection that the delusion of marital infidelity and jealousy may not be accompanied by any noticeable degree of impairment of judgment and mental enfeeblement, and in these cases it may be extremely difficult to make a differential diagnosis between alcoholic insanity and true paranoia.[14] Particularly is it difficult to recognize paranoia with subsequent or coincident alcoholic indulgence.

In this state of persecutory insanity, the patient may be alternately fearful of impending danger, have anxious and angry states, and only too often reacts by attacking his supposed persecutors. In this condition he becomes a most dangerous, homicidal lunatic, and, under the influence of the delusion that his wife is unfaithful to him, may commit wife-murder.

Occasionally the constant persecutions receive, as in paranoia, a delusional explication founded on egoistic exaltation. If so many persons and such powerful societies (Free-masons, Jesuits, etc.) are interested in his downfall, he must be an important personage, king, ruler, who is to be put down that some pretender may usurp his place. Thus is developed a veritable megalomania.

The prognosis in this paranoid form of alcoholic insanity is not good. If alcoholic excesses have been continued a considerable time after the development of paranoid symptoms, or if the insanity has been preceded by several attacks of delirium tremens and the alcoholic state is well established, the delusions are apt to persist; the mental condition issues progressively into dementia. If, on the other hand, the symptoms are of rapid evolution and immediately on their appearance alcohol is withdrawn they may quickly disappear, only to reappear, however, on the occasion of renewed excesses.

On a groundwork of mental enfeeblement the alcoholic may develop a true expansive delirium which, combined with the signs of alcoholism (ataxia, speech defects, tremor, pupillary anomalies, and muscular weakness), may make the distinction from paresis difficult—*alcoholic pseudo-paresis.* The similarity to paresis is noticeable even when the expansive delirium is absent in cases in which the mental reduction is marked, but becomes greatest when the symptom complex above outlined is ushered in by epileptiform or apoplectiform attacks.

The distinction from true paresis can usually be made. Pupillary inequality is more common and the permanent results of apoplectic insults (hemiplegia, aphasia) more often found in the alcoholic form than in the true.[16] The results of polyneuritis should be looked for and if found suggest alcoholism. The most reliable differential sign is found in the course of the two maladies. True paresis is progressive, tending toward ever-increasing degradation, while in the alcoholic form removal of the poison results very shortly in a remission of all the symptoms, even, in some cases, amounting to a recovery. The symptoms, however, reappear subsequently if drinking habits are returned to.

As a result of chronic alcoholic toxæmia, the symptoms of which are marked throughout by their explosive character, it is not strange that actual convulsions, *alcoholic epilepsy,* should complicate the morbid picture. These convulsions, so far as their individual characteristics are concerned, are indistinguishable from true epilepsy. Occurring, however, in a person beyond the period of adolescence who is addicted to the immoderate use of alcohol, their origin should be suspected. The diagnosis is made clear if they cease upon the withdrawal of alcohol. As this sometimes does not occur the diagnosis can be made only by excluding the causes both of true and symptomatic epilepsy other than from alcohol.

In this connection it is interesting to note that about ten per cent. of alcoholics are thus afflicted[12]; that the convulsions in epileptics the children of alcoholics begin four and one-half years earlier[17] than in those whose parents are not thus addicted, and that alcohol aggravates the true epileptic neurosis.

Less common and more unusual effects of alcohol are the conditions of so-called *trance, automatism, double consciousness, spontaneous somnambulism,* which are followed by *amnesia.* In these conditions the subject of alcoholism may do almost anything imaginable, make contracts, transfer property, commit criminal acts, take long journeys, enter into complicated business or professional transactions, and later have absolutely no knowledge of what he has done. During a protracted debauch the subject may suddenly start off on a journey and travel for hours or days under an assumed name, meanwhile conducting himself in such a manner as not to lead to any comment on the part of those whom he meets. Suddenly, without warning or after a night's sleep, he "wakes up"

* *Mania a potu* and *delirium tremens* are terms which have been used by some authors interchangeably. It is, however, desirable that the term *mania a potu* should be applied only to *acute alcoholic mania,* as delirium tremens is not properly a form of mania but rather an *acute hallucinatory confusion* in which the impairment of consciousness is much more marked than in mania.

to a realization of his true situation with absolutely no memory of how he got where he is or of what he has been doing since he started away from home. As the name indicates, this condition has been described as one of automatism, but a moment's consideration will serve to show that acts of such a complex character cannot be automatic acts. The fact that no recollection remains of what was done has been used to argue unconsciousness, but that is equally inconceivable. Hundreds of miles could not be travelled by an unconscious man without attracting attention. The mere fact that the patient has forgotten what occurred is no reason why he must necessarily have been unconscious. The defect is rather one of memory, except possibly in the very simplest cases, and the patient, though perfectly conscious of what he was doing at the time, has simply lost all recollection of it. The author has been able fully to demonstrate this condition in one case in which the period for which the patient was amnesic lasted three hours, and as a result he is convinced that the same condition might be found to exist in others. Some persons are especially liable to this form of mental disturbance, and it may repeat itself on the occasion of renewed intoxication. Its psychopathological basis is probably a dissociation of consciousness.

The *neuropathic state*, though the most pronounced cause of alcoholism, may be an effect. *Neurasthenia* and *hysteria* may both occur as the result of alcoholism; the former caused largely by the malnutrition and exhaustion following continued over-indulgences (*Erschöpfungsneurasthenie*), the latter often affecting the male sex. In these cases the alcohol probably only serves to bring to light latent hysteria. *Dipsomania*—a periodical impulse to drink—though usually an expression of inherited neuropathy, may probably appear as a functional derangement grafted on an hysterical diathesis as indicated by a recent case cited by Janet [18] of *hysterical dipsomania* (*dipsomanie de forme hystérique*). This periodical tendency is further manifested in those cases in which, after repeated attacks of delirium tremens, there continues to be a periodical return of delirium although the use of alcohol may have been long discontinued (*alcoholic periodic insanity*).[12] These patients grow progressively more demented.

Chronic alcoholism, whether interrupted or not by any of the forms of mental disturbance described in this article, tends to an ever-increasing dementia, *alcoholic dementia*. Mental enfeeblement is a symptom from the outset and is noticeable at first in the æsthetic and moral sphere. The previously proud, well-dressed man becomes slovenly in his habits and unkempt in his appearance. Incapable of the close and continuous mental application of former years it becomes impossible for him to meet the requirements of his business or professional life and lying is resorted to in finding excuses. This is followed by moral obliquities of a more serious nature in which the sexual element is apt to predominate and result in medico-legal complications.[19] Memory is early and noticeably affected. The every-day affairs of life are forgotten, so that the subject of alcoholism neglects to keep appointments, forgets important business engagements, etc. Judgment and the reasoning faculties are similarly enfeebled, until finally the most profound degree of dementia is reached, hastened perhaps by apoplectic insults which are not uncommon.

Pathology of Alcoholism.—The gross pathology of alcoholism has already been indicated. Cirrhotic liver, chronic nephritis, fatty heart, chronic gastritis, arteriocapillary fibrosis, cerebral arteriosclerosis, cerebral hemorrhage, constituting in the ensemble a veritable *senium præcox*.

The microscopic changes in the brain have been studied by various investigators. Vas [20] found central chromatolysis in experimental alcoholism in rabbits. Andriezen [21] found chromatophilia, swelling of the cell bodies, and thickening of the nuclear network. Dehio [22] found chromatophilia. Berkley [12] has found by the Nissl method beginning chromatolysis and by the silver-phosphomolybdate method varicose swellings of the dendrites and disappearance of the gemmules.* Ewing [23] found extreme chromatolysis in spinal, medullary, and cortical stichochromes. In many cells the lesion had advanced beyond simple chromatolysis, the nuclei were eccentric, and the remains of the chromatic bodies appeared as fine granules.

As regards the other elements of the brain Berkley [12] has found degeneration in the walls of the blood-vessels with irregular bulgings; obliteration of the Virchow-Robin or intra-adventitial lymph space and partial closure of the His or extra-adventitial lymph space, thus interfering with the excretory output of the brain. Some of the capillaries were plugged with leucocytes. In many instances the perivenous spaces were so filled with polyneuclear leucocytes as to occlude the venous flow by outside pressure. In connection with the pathology of chronic alcoholism mention should be made of Deiters' cells (the scavenger cells of Bevan Lewis [15]), the distal prolongations of the lymphatic system of the cortex, which by their increased activity help rid the brain of the results of degeneration by excretion into the lymph circulation.

Treatment.—The treatment of *delirium tremens* and the other acute alcoholic psychoses should be supporting: liquid concentrated food predigested if necessary. The bowels should be kept free and the kidneys kept flushed by a goodly supply of fluid. Heart stimulants are often necessary, digitalis, caffeine, strychnine, to combat cardiac failure, and hypnotics to induce sleep and give rest. The latter should be carefully selected with reference to the patient's condition, depressing agents such as chloral giving place to safer ones as trional if there is much heart embarrassment. The after-treatment consists of abstinence from alcohol, tonics, nourishing food, and regulation of the emunctories.

The medicinal treatment of *chronic alcoholism* should be tonic and supporting. Strychnine for a general nervous and cardiac stimulant, capsicum and bitter tonics for the gastric condition and anorexia; attention to the emunctories, moderate exercise, baths, massage, and electricity for their general tonic effect; sedatives and hypnotics with caution, a modified "rest treatment" if there is marked neurasthenia, and later a sufficient amount of mental and bodily exercise to keep the patient healthfully occupied. In this connection serotherapy and hypnotism may be mentioned in passing. The former has given no definite results; the latter may be of some value in cases which exhibit a marked hysterical diathesis.

The matter of isolation is an important one. The author feels convinced that in all cases in which the habit is firmly fixed isolation is highly desirable if not imperative, as in these cases the patient is unable to resist temptation and, as soon as an opportunity presents itself, will lapse. After confinement for a few months, during which the patient is restored as far as possible to physical health, he is in condition to abstain if he wants to and is able; if he does not wish to or if he suffers from too great weakness of will, he will return to his old practices and his case is hopeless. If he does wish to stop drinking, however, he has been given the best possible opportunity, an opportunity which should be early extended in all cases and not offered when by long-continued indulgence the case is of necessity hopeless.

II. Opiumism.—*Causes.*—As in other varieties of narcomania the most important cause is the neuropathic diathesis. In this class of patients the habit is often initiated by the use of morphine to relieve the periodic pains of neuralgia, tabes, dysmenorrhœa, rheumatism, etc., or the mental depression incident to worry, loss of position, grief, and the like. A great many cases are unfortunately traced to the carelessness of physicians in prescribing the drug, and as if in retribution medical

* In this connection see article, by Weil and Frank, "On the Evidence of the Golgi Methods for the Theory of Neuron Retraction," Arch. of Neurol. and Psychopath., vol. iii., No. 3. The authors take the position that varicoseness of the dendrites and disappearance of gemmules as shown by the Golgi method are artefacts.

men furnish the largest quota of sufferers (fifteen per cent.).[19]

Symptoms and Diagnosis.—The symptoms of a single dose are at first those of mild stimulation of the mental faculties followed by a period of quiet, half-waking, half-sleeping, interrupted by multiform pleasant hallucinations (predominantly visual) which show no tendency to delusive elaboration in the waking state.[14] This condition is followed by malaise, headache, dry mouth, constipation, and nausea.

The physical and mental disorders resulting from long-continued use are well formulated by Peterson.[4]

Physical.—1. Anorexia and constipation (later diarrhœa often). 2. Cachectic anæmia. 3. Cardiac intermittence, and bradycardia. 4. Muscular weakness with tremor. 5. Miosis in the early stages, mydriasis later, with sluggish reaction of the pupils. 6. Impotence. Amenorrhœa in women. 7. The knee-jerks are often absent. 8. Diminished sensibility to touch and pain, and concentric limitation of the visual fields. 9. Headaches and localized shooting pains, neuralgias, and paræsthesias. 10. Sensation of feeling cold.

Psychical.—1. Simple elementary illusions and hallucinations, muscæ volitantes, tinnitus aurium. 2. Loss of will and æsthetic sense, irritability; moral perversion, as in alcoholic psychic degeneration, but with little failure of memory. 3. Diminished attention, incoherence of ideas, and easily fatigued intellectual powers.

The diagnosis can often not be made without the anamnestic data. The patients frequently deny their habit—mendacity is a prominent symptom, and they are often 'cute enough to find means of indulgence even though carefully watched. The moral degradation is pronounced and they will go any length to obtain their drug. Symptoms which should excite suspicion are periods of torpor and languor (*Schlaffheit*) in marked contrast to the activity of alcoholism, amounting at times to an inability to even sit up, occasional signs of stimulation, small pinpoint pupils, yellowish-brown cachectic complexion, and, above all, the numerous scars of hypodermic injections.

Psychic disturbances develop more often as the result of abstinence than of continued use. They may be characterized by predominating depressive (melancholia) or exalted (mania) effects, or a paranoid state may develop. As in other toxic psychoses there are apt to be present more or less confusion and a tendency to multiform hallucinations. Dementia is a rare sequel.[9]

Prognosis.—The prognosis is not good and except in such cases as are not complicated by neurotic or psychopathic taint or disorders relieved by opium, recovery is hardly to be expected.

Pathology.—Opium has much less tendency to produce tissue degenerations than alcohol and many persons continue for years to take small doses with no apparent harm. Ewing[23] has found in the autopsies diminution of the amount of chromatin, and a tendency to central chromatolysis (in alcohol the tendency is to peripheral chromatolysis[24]), minute subdivisions of the chromatic bodies and eccentricity of the nuclei.

Treatment.—The treatment of morphinism has to do with the removal of the drug and the symptoms of abstinence. Isolation is more necessary than in alcoholism as these patients make more effort to obtain their accustomed stimulant surreptitiously. It is well, in accordance with the suggestion of Dercum,[25] not to begin stopping the drug until the patient has been under treatment for a time, confidence established, and the general health raised to the best standard. The *ration de luxe* can then be rapidly withdrawn, in accordance with the method of Erlenmeyer,[26] leaving the patient on about 0.15 to 0.20 gm. morphine per diem, below which amount serious symptoms are apt to present themselves. From this point on the withdrawal should be gradual. Symptoms of abstinence, if they appear, are referable to the heart, stomach, bowels, and nervous system; they are circulatory failure, respiratory disturbance, pyrosis, vomiting, diarrhœa, tremor, general debility, an hallucinatory delirium, and sometimes profound collapse. Ball[27] has called attention to pollutions and erotomania which may result from abstinence. For the cardiac weakness digitalis or sparteine hypodermically should be used, for the pyrosis bicarbonate of soda; vomiting and diarrhœa should be treated in accordance with general principles (bismuth, etc.), opium being avoided. If the mental and physical symptoms become grave morphine should be given and will usually relieve them. The evening dose should be omitted last, to combat any tendency to insomnia, and full feeding, massage, and Turkish baths are valuable adjuncts.

Meco-narceine (Duquesnel's solution) has been used by Jennings[23] as a substitute for morphine for a few days only after entire discontinuance. It is unnecessary to call attention to the danger of cocaine for this purpose. Codeine has also sunk into disuse and the recently synthetized derivatives of morphine, heroin and dionin, cannot be said to be any better. Their use is founded on a wrong theory and is fraught with danger. Cases of serious addiction to codeine and heroin have been reported.[28]

III. Cocainism.—*Causes.*—Addiction to this drug has in a great many cases come about by attempting to substitute it for morphine, and as a result pure cases of cocainism were formerly more rare than at present. Cocaine has been used so much of late in dentistry, minor surgery, and especially nose and throat work, that knowledge of it has become more or less general. The victims are usually those who have commenced its use for its analgesic effects and are largely physicians.

Symptoms.—The symptoms resulting from the use of cocaine are those of marked stimulation. The pulse is increased, pupils are dilated. The patients are active and extremely talkative, often repeating their remarks a number of times; they are constantly busy (*Vielgeschäftigkeit*), some of them writing endless letters, and their whole appearance indicates an acute intoxication. The effects are, however, very fleeting and the dose has to be frequently renewed. Chronic addiction results in marked emaciation, cachectic anæmia, insomnia, sometimes epileptiform attacks,[29] and various paræsthesias, the most marked of which is a sensation of crawling under the skin ("cocaine bug"). In the psychic sphere occur incapacity for mental application, lessened moral sense, mendacity, irritability, impaired judgment, and sometimes the delusion of marital infidelity. These symptoms may be followed by mental confusion with hallucinations, but more characteristically by a paranoid state (*hallucinatorische Wahnsinn*). From true paranoia this is differentiated by the greater variety of delusions, those of paranoia being less variable, rather noticeable for their monotony.[14] In the paranoid state of alcoholism, on the other hand, the hallucinations are more stereotyped.

The abstinence symptoms are not so severe as with morphine and may not appear for several days.[30] Erlenmeyer[31] has called attention to a profoundly depressed, lachrymose, demoralized condition, with moaning and sighing which may supervene. The persecutory delirium may persist for a long time and constitute the patient a very dangerous individual.

Morphine and cocaine addiction may also produce a neuropsychopathic state with symptoms of cerebral neuræsthenia—morbid impulses, insistent ideas, etc. The author has recently had such a case under observation, in which the patient suffered from a convulsive tic with mental depression and suicidal impulse. Recovery followed prolonged abstinence.

Treatment.—Isolation should be insisted upon. The drug may be withdrawn rapidly as the symptoms of abstinence are not marked as in morphine. The prognosis of deprivation is good, but relapses are pretty apt to occur.

IV. Miscellaneous Intoxicants.—Various other drugs may produce marked mental disturbances as a result of acute or chronic poisoning or habituation. The limits of this article permit only of their mention. They are chloral, cannabis indica, somnal, sulphonal, paraldehyde, ether, chloroform, antipyrin, phenacetin, trional, chloralamid, iodoform, belladonna, hyoscyamus, salicylic

acid, quinine, the preparations of lead, arsenic, and mercury, and the bromides.

The mental effects of poisoning from all of these is in the main an acute hallucinatory delirium with more or less confusion. If recovery is not complete a paranoid state may persist. *William A. White.*

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XII. INSANITY: GENERAL PARALYSIS OF THE INSANE.—General paralysis of the insane, also known as paretic dementia, dementia paralytica, and popularly as paresis (which term for convenience will be used largely in this article), is undoubtedly an old disorder, but its recognition as a distinct type dates back only to the early years of the nineteenth century. The occurrence of paralysis with insanity apart from that associated with gross organic disease of the brain had been noticed by earlier observers, but it is to Bayle (1822) and Calmeil (1826) that we owe the first definite recognition and description. Since then it has been, more than almost any other type of mental disorder, a special study of the alienist, and its literature has surpassed in extent that of any other. It has been called a disease of modern life on the presumption that only in comparatively recent times has it become prevalent, and there is much apparent reason in this presumption. Certainly only of late years has its prevalence been so notable, and its actual increase seems to be a fact that cannot well be contested, making all due allowances for defective diagnosis which undoubtedly affected the statistics to some extent up to within a comparatively recent period.

The definition of general paresis presents some difficulties. In the first place, it is a protean disorder and its symptoms have often in the past suggested to alienists that we have in it not one but possibly several distinct morbid entities. This, in fact, has been the contention of some of the French writers, and it is still maintained by some that the paralysis and the dementia indicate two distinct types. The pathology of the disease has also been in dispute, so that neither on clinical nor on pathologic grounds has there been up to a very recent date a basis for positive assertion of the unity of the disorder. The close relations, however, with tabes, and their apparent convertibility in some cases with the more recently acquired facts in regard to the pathologic processes in the neurons in the latter affection, have of late years thrown much light on paresis. Among the very latest investigations in this direction are those of Mott, who holds that paresis is a disorder primarily due to a degeneration of the neuron itself, a parenchymatous degeneration, with secondary inflammatory changes affecting the vessels, lymphatics, and membranes, due to the irritation of the products of nerve decay. Accepting this theory of the disorder, which seems, in view of all the facts, as possible as any, we may define paresis as a generally subacute inflammation of the brain, due primarily to toxic degeneration of the nerve elements, especially those of the higher cerebral centres (speech, ideation, etc.), and generally attended with a chronic progressive dementia and physical paresis with manifold other mental, sensory, and motor symptoms, and ending inevitably in death from general exhaustion or from one or other of the special cerebral complications incident to the affection—acute delirium, convulsions, apoplectic attacks, etc. —or from intercurrent complications. The fundamental conception of the disease is the special nerve-cell involvement as the essential lesion of paresis, the other pathologic conditions being secondary. It does not necessarily follow that other pathologic conditions may not simultaneously appear and coexist with the degeneration of the neuron, but they are not the disease itself.

Etiology.—*Predisposing Causes.*—The first, if not the only, place in the causation of general paresis must be given to syphilitic infection. It is true that many, while recognizing the importance of this factor, nevertheless deny that it is by any means universal. The earlier writers on the subject, as a rule, paid but little attention to luetic infection among the causes of the disease; it was only incidentally mentioned by Bayle, and Esquirol recognized it only as contributing indirectly through the overuse of mercurial treatment. Sandras, however, in 1852, called syphilis and intemperance the two great causes of general paralysis; and some years later several Danish physicians, Steenburg, Esmarch, Jessen, and Kjellberg, announced their belief in the specific nature of the disease. Most authorities, however, up to the last two decades have put syphilis in the background, and it is only within that period that the compilation of numerous statistics indicating its frequency as an antecedent has brought it prominently to the front. In 1886 Rieger deduced from such figures as were then available the causal relation of syphilis, showing that the liability to paresis of those infected was sixteen or seventeen times as great as that of non-syphilitics. Since then the evidence has become much stronger, and a much higher ratio could be easily deduced. In 1891 the writer, analyzing the data afforded by the histories of two hundred and thirty-four paretics in the Illinois Eastern Hospital for the Insane at Kankakee, Ill., found a sufficiently clear evidence of syphilis in seventy-two per cent. of those cases in which any data could be obtained, and strong indications or probability of it in seventeen per cent., leaving only eleven per cent. in which there were no positive facts or probability. This did not imply that syphilis could be positively excluded in any case, but simply meant that there was no other evidence pointing to it than the existence of the paresis. Hougberg's figures are almost identical; he analyzed the facts in regard to exactly one hundred paretics, all that were on the records of the Imperial Lappvik Asylum, at Helsingfors, Finland. Of this hundred paretics, seventy-four per cent. had a clear history of syphilis. Twelve more had a less definite record of venereal disease, "ulcus mollis," gonorrhœa, or had been treated in the venereal wards of a hospital. Of the remaining fourteen, eleven had been dead ten years or more, and facts as to this special point were not so accessible as in the more recent cases. Nevertheless, several of them had a record of what appeared to have been possibly antiluetic treatment with the iodides, and others were of the classes that furnished a large proportion of paretics or had had apoplectic attacks in early life or had lived irregularly. One of the remaining three was sixty-three years of age, which arouses a suspicion of organic senile changes rather than paresis, and the other two were as it were waifs, only a short time under observation and lacking history. Any or all of these may have been syphilitics, as Hougberg says; it could only be said that it was not

in the histories that could be obtained—they were simply non-committal on this point.

Hougberg's statistics have been often quoted, and they are especially valuable since he took particular care and apparently had special facilities in looking up the antecedents of his cases. They are amply supported by recent statistics, though there are still some investigators who appear to have trouble in finding syphilitic antecedents in their cases. Berkley, for example, finds only fifty per cent. of proven and doubtful syphilitics altogether, and some French authorities have reported ridiculously small figures, making syphilis much rarer among paretics than among the general population. The tendency of medical opinion, however, of late years is to make this disorder the chief if not the sole predisposing cause, and Krafft-Ebing's catch phrase of "syphilization and civilization" as the primal causes of paresis is taken seriously to a large extent. The proof of the importance of syphilis is not confined to statistics. There are other facts almost as strongly indicative, such as the rarity of the disorder where syphilis is unknown, and among classes that are least liable to it, and the converse—its frequency in cities and rarity in rural districts, the cases of juvenile paresis in hereditary syphilitics, and those of conjugal paresis where both husband and wife are alike affected. All these point strongly to syphilis as a necessary antecedent, though the evidence is not complete enough to say positively that it is universal. The lack, however, of evidence of syphilitic infection in a certain proportion of cases is less important when we consider the difficulties of obtaining information as to this in a very large proportion of undoubted cases of the disease. It is probable that those who have reported only a small percentage of syphilitics among their paretics did so on a comparatively limited information, and had they had the opportunity and the will to investigate more thoroughly their percentage would have been much larger. It is possible also that other toxic agents besides syphilis may occasionally produce the disease, or rather, we should say, prepare the way for it. While we are, perhaps, not fully prepared to say with Möbius, Sachs, and others that there is no paresis without prior lues, they are far more justified by the facts than are those who deny or disparage its agency.

Another factor in regard to which there are varying statistics and widely differing opinions is heredity. The reported frequency of hereditary insanity, neuroses, etc., ranges from thirty to seventy per cent., or even exceeds these limits. Some continental authorities, French and Italian, have attributed much importance to a cerebral congestive heredity, and Naecke considers that a certain cerebral predisposition, not very well defined by him, is one of the commonest and most essential conditions of its occurrence. Berkley seems to adopt this view, and considers this heredity as congenital predisposition one of the most important etiologic factors. The writer, in an analysis of over two hundred cases, found less than half of the amount of neurotic or vesanic heredity than was met with in ordinary cases of insanity, and this included search for evidence of the so-called congestive heredity as well as that of insanity or other neurotic predisposition. It is very probable that any cerebral weakness, such as that claimed to exist by Naecke, would predispose to the disease in conjunction with other etiologic factors, but I am doubtful as to its occurrence as a rule in paresis. Except in juvenile paresis, which is directly dependent upon a specific heredity, it seems to me most correct to attribute less importance to this element in this disease than in other forms of mental derangement.

Age has a certain obvious influence in the incidence of paresis. It is pre-eminently a disorder of the active period of life, most cases occurring between the ages of twenty-five and forty-five. This is the period of special stress upon the nervous centres, the time during which the brain is most taxed, and when overwork, anxiety, exposure, and dissipation are making their drafts upon the nerve centres under the stress of modern civilization. After fifty paresis is rare, and though cases are reported after sixty, the writer has never seen one that was clearly this disorder; certain cases of senile organic change in the brain cells often simulate paresis, and are probably responsible for some of the cases diagnosed in patients of advanced age. Juvenile paresis, occurring about the age of puberty or rarely earlier, is always the result of inherited syphilis.

Sex and occupation are also generally included among the predisposing causes of the disease. The great majority of paretics are males, but its increasing frequency among women is a common observation in more recent times. Women are less exposed to the exciting causes than men, and it is a noteworthy fact that in this country at least the majority of female paretics are married women, and a syphilitic history can sometimes be found and more often suspected in their married partners. Of the unmarried female paretics, many are prostitutes, who seem to be especially liable. Of three personally known to me, one was, I believe, of this class, and one of the others had had an illegitimate child.

Certain male occupations seem to favor the occurrence of paresis, and they are the ones, as a rule, that conduce to irregular habits, sexual, alcoholic, etc. Commercial travellers, railroad men, speculators, men about town, etc., furnish a large proportion of all cases, while clergymen, Quakers, farmers, etc., furnish few or none. It is a disease of cities rather than of the country, where, though morals may not be always better, syphilis is less prevalent and life is simpler and less intense. Race in itself has probably very little to do with the etiology of paresis, though much has been made of the apparent exemption of certain peoples in the arguments against the syphilitic origin of the disease. It is not only the predisposing causes that are requisite, but also the exciting causes, and if either are lacking the disease is not likely to appear. Syphilis is common among the Egyptians, but paresis is rare; but there is little in their uneventful lives to cause the strain on the nerve elements that is required, and the fatalism of the Mohammedan is also a safeguard. While it is believed by many specialists that the Jews are less frequently affected with syphilis than those of any other race and religion, Beadles finds them in London specially liable to paresis, which he attributes largely to their trading and speculative tendencies. Many of them, moreover, come to that city from sections of Europe where syphilis is very common and one might say endemic, so that they do not necessarily escape special risks of infection.

Reviewing the predisposing causes of paresis, the first place must be given to syphilis; it is a question, indeed, whether it is not an essential cause. Heredity can be regarded only as a secondary and non-essential cause, and the others—age, race, occupation, etc.—are of importance only as related to the other two.

Exciting Causes.—The exciting or immediate causes of paresis are numerous, but one stands pre-eminent; that is, mental overstrain and worry, including under these the stress and anxiety of business and the struggle for existence under conditions of modern civilization. The best proof of this is the fact that paresis is almost exclusively a disease of civilization and almost unknown among barbarians and populations living under simple conditions; it is a disease of cities, where the struggle for life is keenest, and rare in rural districts and away from the temptations and excitement that abound in the great centres. There are also direct evidences of the fact that mental strain is one of the chief exciting causes, if not the chiefest, in the personal history of paretics; anxiety, business worries, etc., are among the most commonly ascribed causes. As syphilis and other predisposing causes, however abundant, are apparently powerless to bring about paresis alone, some additional factor is required, and the last straw that breaks the back of the weakened nerve element in this disease is most often supplied by some mental strain, most commonly that of the class of which worry and anxiety are the types.

Alcoholic excess has been recognized as a cause from a very early date, and undoubtedly is an important fac-

tor in many cases. Its importance, however, has been exaggerated. Alone it seems to have been powerless in the past, when such excess was far more prevalent than in many regions where of late years paresis has made its greatest advances. In combination, however, with other factors, its influence is not to be underestimated, and it has been a precedent in a very large proportion of all the occurring cases. It is very natural to assume its action in producing the disease, since it is well known that a very similar though transitory clinical picture is sometimes produced by it alone. The chronic incurable paralysis with dementia of chronic alcoholism has in it also some suggestion of that of paresis, though the differences are wide enough to make the distinction between them easy.

Sexual excesses are another commonly attributed and no doubt an important cause. There is often a history of such excesses, but its significance is sometimes lessened by the fact that it is itself an early symptom of the disorder. Unless the history of sexual debauchery goes back over a considerable period of time, as it often does, too much weight may easily be given it as a causal factor. Mott, one of the latest writers on the subject and one whose work is in many respects the best as well as the most modern, considers this element in the etiology very important; excesses of this kind, he holds, may deprive the brain cell of what is directly essential for its nutrition. By itself, however, it is ineffective. Lechery of the most abandoned and abominable type has always existed among men, and in past ages even more than in the present, but paresis is essentially a modern disease.

It is a question sometimes disputed, at least by inference, whether syphilis may be a direct exciting as well as a predisposing cause. Cases with the clinical picture of paresis occurring after recent syphilis or in connection with its secondary or tertiary manifestations are classed by some as syphilitic pseudo-paralysis, a term introduced by Fournier but practically discarded by him in 1894. It is customary with many writers to point out diagnostic features of this type as distinguished from true paresis, some of which at least are certainly fallacious, and none according to the writer's experience absolutely reliable. It does not appear, however, to him that there is any impossibility or improbability of the genuine disorder appearing after recent luetic infection, unless we can show the impossibility or unlikelihood of the special disorder of nutrition of the nerve elements which we consider the essential lesion occurring except after a lapse of years. Cases do occur with every symptom characteristic down to the resistance to treatment and the fatal outcome in connection with comparatively recent syphilis, and the most natural course is to recognize them as true paretic cases. It seems therefore correct to include syphilis with other commonly recognized exciting causes, as trauma and sunstroke, but there is generally back of these last some other well-marked factor, and usually, if the facts can be ascertained, a luetic history.

The etiology of paresis or general paralysis is one of the most important subjects in connection with the disease; hence the space here given to it. The disease is practically incurable and fatal. Prophylaxis is the only real defence, and this depends upon its etiology. Summing up what we know and the legitimate deductions from the same, I think it can be said that while there is a possibility in exceptional cases of some other toxic agency exciting it, in by far the greatest number, and practically in all, it has syphilis as its essential antecedent. In most cases this seems to act by preparing the way, creating a condition of susceptibility to other active causes, usually after the lapse of years. These later factors may be various, but among them and probably cooperating in nearly every case is the element of mental stress, either as overwork, worry, or the excitement of the demands of modern civilization generally acting on the weakened nervous organization. Heredity, except as hereditary syphilis in juvenile paresis, probably plays only a subordinate part—less, indeed, than in other forms of mental disease. We cannot altogether neglect, however, the possibility of all the factors together working on the heredity of the race and producing a class of more easy victims of the disease. There may be something in Naecke's supposition of a congenital brain weakness tending specially in this direction.

Symptomatology.—It has been already remarked that paresis is a protean disorder. Its beginnings are insidious; as Regis says: "There is perhaps no disease that begins more gradually than general paralysis. Except when it begins with a congestive ictus its invasion is so gradual and insensible that it is almost always impossible to fix its real commencement, and its origin is lost, so to speak, in the darkness of the past." It is unusual to find the earlier manifestations reported in the histories, and at best it is the rule to obtain only vague impressions or indistinct recollections of facts. Sometimes, as intimated in the above quotation, the first thing noticed is a maniacal, convulsive, or apoplectiform attack; but it is probable that in some of these cases there was a gradual deterioration preceding the insult, which passed unnoticed even by friends and intimates.

It is customary in text-books to describe three stages of typical paresis: the preliminary or incubatory stage, the stage of active bodily and mental symptoms, and that of final paralysis and dementia. To a certain extent this division is justified, but the cases of abnormal course in which these stages are not clearly defined are so numerous as almost to invalidate the rule. In a very large proportion, however, there is a period in which the disorder is only partially developed though it has a wide range in its symptoms. As a rule the very earliest beginnings, as already said, are little noticed even by the patient himself, and sometimes the fully developed stage of the disorder seems to break out without any prodromal symptoms whatever. The first symptoms are perhaps as often as not indistinguishable to the observer from those of neurasthenia. The patient feels himself somewhat incapacitated, his memory is less acute, his capacity for mental exertion is diminished, he complains of nervousness, sleep may be unsatisfactory, he may complain of obscure neuralgic or what he takes for rheumatic pains, headache is not uncommon, and most authorities mention it as occurring especially in the frontal and vertical regions. Vertigo is often complained of. The system often seems to the individual generally out of sorts, there may be dyspeptic symptoms and constipation, or other irregularities. At first the incapacity is noticed only under stress of work, but after a longer or shorter time it becomes so constant and prominent that he may give up work or have to abandon it. In some cases there are spinal symptoms resembling those of locomotor ataxia, girdle sensation, and occasionally actual ataxia and pupillary symptoms or other ocular paralyses appear at this stage, to disappear later or to become less conspicuous with the advance of the cerebral disorder. Berkley specially cautions practitioners as to their diagnosis of neurasthenia in a patient in middle life who presents reflex pupillary disturbances. Anisocoria, which in the developing or developed stage of the disorder is a frequent pupillary symptom, may appear in normal individuals, so that its special significance by itself is not so great as that of some others. An absence of the light reflex, the so-called spastic myosis, is far more significant but is not so prominent to the casual observer. The pupils are small, the reaction to light is absent or sluggish, and this symptom may be one of the earliest of all to appear. The alienist or even the physician in general practice so rarely has the opportunity to observe the earliest precursory phenomena that it is well to bear this symptom in mind. Other facial signs noticed in the beginning are occasionally a peculiar lack of expression in the features, hard to describe but quickly recognized by an experienced eye. There seems to be already a partial paralysis of the muscles of expression, not analyzable into defects of special muscles, but rather uniformly involving all. This becomes marked in the later stages of paresis, but sometimes may be detected early. The reflexes, tendon and cutaneous, are apt to be exaggerated

in this early stage, at least in the purely cerebral phase of the disease, but this is in accordance with the neurasthenic type prevailing. A fine tremor may also exist in this preliminary stage, though it is not often remarked till later, when it becomes a prominent feature.

The earlier mental symptoms of the prodromal period are also of the neurasthenic type—inability to perform mental labor, lack of power of sustained attention, defects of memory noticeable in little things, and in recollection of recent events, etc. The intellect may be apparently clear on most things and the patient be conscious of his slips of memory and other defects, and consider himself only a victim of nervous prostration. There is marked increase of irritability as a rule at this time, and, what is of some significance, a degree of moral defect is occasionally very evident, sometimes showing itself in a neglect of the minor proprieties of life, but often also in an apparent loss of moral inhibitions in higher matters. The tastes may change, and the individual, from being refined and fastidious, may take up coarse indulgences, become careless in habits and gross in his appetite, vulgar in speech, and sometimes show a decided sexual depravity. The altruistic emotions, family affections, etc., may be noticeably impaired or lost, and a disgusting egotism be manifested in many ways. The upright honorable man of business may become utterly unreliable and tricky, and the sedate father of a family indulge in undignified and open immoralities—all this before there have been enough other symptoms of intellectual or physical derangement to cause their friends to suspect their real condition. This is, however, not always the case; the moral lapses may be slight, and only the gradually advancing general weakness or neurasthenic symptoms call attention to their disorder. Sometimes only the minute but important physical defects in manual dexterity are the chief ones noted; we have seen a stenographer affected with incipient paresis in whom, aside from a decided emotional depression, an inability to take notes accurately and quickly from dictation was almost the only noticeable symptom of this entire stage.

The emotional depression mentioned above is a common feature in many cases, and may be taken for a sort of neurasthenic melancholia, the depression masking the other symptoms. Sometimes the mental disturbance is hypochondriacal in type, and this may extend well into the later stages after the physical symptoms are well advanced. There is every variation in the degree of intellectual impairment; in some exceptional cases it may seem to be slight even late in the disorder, so that a general paralysis without dementia has been spoken of by some writers. As an almost universal rule, however, mental defect to a greater or less extent is detectable on careful observation even in the earlier stage, and is the characteristic feature throughout the disease. It shows itself in the fatuous business projects, the confusion of ideas, the lapses of memory and propriety. It is also seen frequently in the writings, which sometimes show characteristic traits of mental failure, not only in their substance but in dropping of words, or letters, incomplete sentences, etc. They may also give evidence of the physical breakdown in a fine tremor which is characteristic even in this early stage, as already mentioned.

The Developed Disease, First Stage.—The transition into the second stage (first of some authors) is usually gradual and the distinction between the two not always marked. We may say that a good landmark showing the full onset of paresis is to be found as much as anywhere in the alteration of speech. When this becomes noticeably or even slightly embarrassed in the pronunciation of words demanding the use of the labials and dentals, the condition is recognizable by any one with the slightest experience. It is not only the difficulty of producing certain articulations, but a general defect of co-ordination of speech muscles that causes a peculiar thickness of utterance noticeable in any attempt at articulation. The patient will have special difficulties with some sounds, words like "National Intelligencer," "Peter Piper picked a peck of pickled peppers," etc.; he will stammer and fail and try to repeat, but the pronunciation of all words will be also affected. There is a defect of co-ordination of the muscles involved, together with a partial paresis, central in its origin. This symptom varies in extent in different patients; in some the speech alteration may be comparatively slight, but it is sufficiently frequent to be characteristic, and can be detected in some degree in nearly every case.

The muscles of expression are still more involved than in the prior stage, and irregular twitchings and local paralyses, lasting or temporary, are observed. There may be ptosis, one side of the face may be more affected than the other; tremors of all the facial muscles and of the limbs are characteristic of this stage. Manual dexterity is apt to be lost or very much impaired in special acts, such as those required in a trade or in the arts, all on account of the loss of co-ordination of the finer cerebral mechanisms. The muscular power in itself is not so much impaired as is the controlling power. The patient may feel well, all the bodily functions may be carried out, sleep, appetite, digestion, and excretions be normal or apparently so, for a considerable period after this disorder has thus fully developed; the reflexes differ little from those of the initial stage—that is, they are variable, the neurasthenic exaggeration may continue in the deep reflexes, or they may be diminished or lost. The pupils are unequal in a very large proportion of cases at this period, and may continue so to the end; in other cases there is myosis, such as is common in the earlier stage. In some cases the Argyll-Robertson reaction is marked. There is no regular febrile movement, the temperature may be about normal, except in connection with some accident of the disease, convulsion, or apoplectiform attack.

In a few cases ataxic symptoms precede the outbreak of paresis, as already mentioned, and they may occasionally appear in this earlier period of the fully developed disease. Their early occurrence and subsequent disappearance seem not to have been noticed by the earlier writers; the tabetic type has been generally recognized only of late years. Its comparative rarity accounts in part for this, and the fact that the tabetic symptoms are probably prominent only in the earlier ante-asylum stage is sufficient for the rest. It is, in fact, not of special importance, except as showing the relationship between the two disorders, paresis and tabes. Out of nearly two hundred and fifty cases under the writer's personal observation, definite tabetic symptoms occurred only in three, though it is possible the number might have been increased had full data as to the earlier manifestations been obtainable. In this form or stage—the ascending spinal type—the knee reflex is absent.

The congestive or apoplectiform and convulsive attacks which may occur, and which as previously stated may be sometimes the earliest manifestation, are most frequently seen after the paresis has fully developed. The apoplectic insults are less frequent than the convulsions, and, as a rule, more serious. Their onset is sometimes similar to an ordinary hemiplegic attack, though the unilateral paralysis is not always complete. There may be no loss of consciousness. A more characteristic paretic type is one in which the patient becomes suddenly or gradually comatose, with hot skin, stertorous respiration, and this leaves behind it a temporary paralysis of one or more members and generally a permanently more or less deteriorated mental condition. Or there may be only a temporary coma or somnolence of varying duration without very appreciable sequels; there is no regularity in the type or the results. I have seen a patient hemiplegic on one occasion and only aphasic on another, each time for the space of a few hours, but appreciably worse mentally after each attack. Occasionally these attacks are serious, and death may occur in the first seizure both of the congestive and the convulsive types.

The epileptiform attacks may occur singly or in rapid succession; the latter is a frequent type in the later stage of the disease. In either case they are often very similar in their appearance to those of epilepsy. They may,

however, be fatal, and are usually followed by an aggravation of existing mental and bodily symptoms.

The mental symptoms of the fully developed stage are a continuation of those of the later prodromal period. Usually before the physical signs of the developed disease have become well marked, the extravagances of conduct and of advanced dementia and evident delusions have made the insanity manifest to friends and the public. In fact, the mental often precede the physical symptoms. Some patients pass gradually into an active delusional insanity with comparatively slight physical symptoms, others have some of the bodily symptoms very pronounced with apparently little intellectual impairment. Most patients, however, after the speech defects have become permanent or after a period of months, or it may be of years, of the condition described as the preliminary stage, begin to exhibit an intensification of their mental symptoms. The tendency toward dementia becomes evident, and a peculiar delusional type is often developed, there are grandiose ideas of wealth, personal ability, etc. These may have existed before to some extent, but they now become conspicuous, and in the beginnings of this stage the mental state may closely resemble that of acute simple mania. With the abnormal excitation of the faculties, however, there is a more pronounced element of mental weakness and confusion than is the case with the acute maniac. Later, as the bodily symptoms develop, the dementia is more prominent, the mental activities take on the delusional form, and the extravagance of the patient's fancies is uncontrolled by any element of reason or recognition of possibilities or probabilities. It is not usual in this stage to see fixed and consistent paranoic conceptions, though in some instances such occur. In the majority of this type of paretics the delusions are unsystematized—they are the expression of the exalted self-consciousness of the individual and the advancing incapacity to recognize the true relation of things. These patients are possessors of billions of dollars, have mines where coined double eagles are dug out by the ton, are husbands of thousands of wives, own all the railroads, are the greatest orators and authors, have converted millions by their sermons, etc., all given out as gospel truth in rapid succession it may be by the same individual. This unsystematized and extravagant character of paretic delusions is a feature of the disease in so large a proportion of the cases that it has been held and is still often considered to be the special characteristic of the disease. Not less frequently, however, at least of late years, other types of mental disturbance are observed. In a certain proportion of cases this is of a depressed type throughout, and often a hypochondriacal extension of the neurasthenic depression of the earliest phase. These patients may show a mental weakness only and a general tendency to exaggerate and invent morbid feelings; any slight ailment or injury disturbs them unduly and is sometimes the direct occasion of an outbreak of delirium. In other cases there are the self-accusatory delusions and feelings of unworthiness, as in melancholia, which is strongly suggested; and in still others only a progressive dementia from the beginning to the end of the disease. Occasionally paresis assumes a circular type of alternating excitement and depression, and there are cases in which fixed delusions resembling those of systematized delusional paranoia occur and continue throughout a considerable period. I have seen a paretic who for five years remained in a stationary condition with fixed moderately exalted delusions, pronounced visual hallucinations of angels, deities, etc., a rather prominent general dementia, speech disturbances marked, pupillary inequality, and a generally good physical state as regards nutrition, the digestive functions, etc. Then he rapidly passed into the third stage, became paralytic, and soon succumbed.

It is difficult to estimate the proportion of paretics in which the disease assumes the exalted and the depressed or demented types; but while the former is usually considered the most typical, it is certainly not the most frequent. The demented type, in which the mental symptoms are predominantly those of steadily progressive mental failure, is perhaps as frequent as any; Kraepelin estimates that it includes over forty per cent. of the cases according to his experience; while the exalted form includes only fifteen or sixteen per cent., or, taking in the more acutely maniacal cases which he classes as the agitated type, about twenty-six or twenty-seven per cent. The depressive type he finds to occur in about twenty-seven per cent. of all cases. The purely hypochondriacal and the circular cases and those with only comparatively slight intellectual disturbance even with marked physical symptoms form a still smaller contingent, but they exist as a class and may be reckoned according to the writer's observation as forming two or three per cent. of the whole. The difficulty in any classification is the large number of cases in which the symptoms are at one time of one type and at another show a quite different aspect, so that it is not easy to say in just which class they belong. In women these irregular forms are proportionately more frequently observed than in men, but the number of female paretics observed by me has been so small that a positive generalization is hardly justifiable.

Sensory symptoms may occur at all stages of the disease after it has once developed. Anæsthesia and analgesia are not uncommon in advanced cases, and various paræsthesias may occur in the earlier stages. Disorders of special senses are common, especially of smell or taste; depraved appetites are often observed. The sexual appetite is sometimes exalted in the excited cases, seldom so in the depressed, and rarely if ever in the progressive dementia type (Marandon de Montyel).

Hallucinations are not so prominent in paresis as in some other forms of insanity, but they occur in a considerable proportion of all cases. In the agitated type of either expansive or depressive delusion they are apt to be manifest. In the agitated depressed cases visceral hallucinations are comparatively common, the patients complaining of having cats, dogs, reptiles, etc., inside them, and in women delusions of pregnancy are aroused. Sometimes visual and auditory hallucinations are also common, but are not so strikingly frequent, except in the delirious attacks.

A not very uncommon feature in the fully developed stage and sometimes beginning it are the occasional attacks of acute maniacal excitement, usually of short duration, but sometimes prolonged over days and even weeks. They may occur suddenly in the night or in the day, and suggest the psychic equivalents of the epileptic. It is quite possible that the mechanism is the same, that they are the equivalents in a sense of the apoplectiform or convulsive attacks, symptoms of special cortical explosions, only that here the objective manifestation is psychic in its character. Like the convulsions or congestive attacks, they are likely to be followed by a usually permanent psychic deterioration,—they accelerate the progress of the dementia.

Of quite a different character are the attacks of acute delirium that occasionally occur at any stage of the disorder. They are sometimes incited by apparently a trivial cause, such as a slight traumatism in the hypochondriacal cases, but they form one of the most formidable complications when they occur. The patient passes into a wild maniacal delirium, often with hallucinations, his bodily activity is incessant and violent, food is refused, insomnia is nearly absolute, sleep being only in snatches from exhaustion, the bodily temperature rises sometimes to an extraordinary height—in a case observed by the writer it was 107° F. in the axilla through the shirt several days prior to death. Toward the close of the scene it falls again as the vital powers fail and the patients succumb to exhaustion, and the rectal temperature may even be below normal some time before death. In some cases, in which the symptoms are less severe, the patient may survive, but like other forms of acute delirium it is generally fatal. When it occurs early in the disease, as it sometimes does, it may form the basis for a diagnosis of "galloping" paresis, some of the reported cases of which are probably examples of this condition. It may be said

here that rapid cases of paresis are not confined to this or to any agitated type, as the convulsive or apoplectic attacks may be fatal almost in the earliest stages of the disease.

Remissions of the symptoms may occur at any time prior to the appearance of complete dementia, and last in some cases for years. Sometimes these remissions are so complete as to suggest recovery, and cases have been reported as such. More often there is a check to the progress of the disease, which still manifests itself in some ways; the patient remains in a stationary condition, and one that in itself alone might not suggest paresis. The longest continuous remission of this kind personally observed by the writer was about five years, which is much above the average, though cases of much greater duration have been reported. After the third or final stage has appeared, remissions are hardly to be looked for.

The passage from the second to the third stage of paresis may be sudden or gradual. Generally, sooner or later, in the second stage, the mental failure becomes more marked and rapid, the paresis more pronounced. The patient becomes neglectful of the ordinary decencies with the advancing dementia, and the third or final stage may be said to have begun. The dementia and the paralysis, however, do not by any means progress *pari passu;* in some patients the dirty habits precede the physical symptoms, and vice versa. In the typical form this third stage is characterized by the aggravated speech defects, increased feebleness and inco-ordination, marked failure of mentality in all respects, as well as by the untidiness. Symptoms of cortical irritation are more frequent, the convulsive and congestive attacks become more frequent and also often more severe, with correspondingly more rapid advances in mental and physical deterioration, tremor becomes more marked, and such symptoms as grinding of the teeth, localized spasm, contractures, etc., are frequent, and the former may be almost constant, nutrition fails, trophic disorders such as bedsores, ulcerations, buttock sloughs, hæmatoma, arthropathies, fragility and fractures of bones, etc., make their appearance. Deglutition is embarrassed, and special care has to be taken to prevent choking from food. Any or all of these symptoms may coexist, and the final stage of all cases which are not carried off earlier by accidents incident to the condition or by intercurrent disease is a gradually failing vegetative existence, ending in death from final gradual exhaustion of nerve centres, with cardiac and respiratory failure or disease of lungs, kidneys, digestive tract, etc.

The average duration of a case of paresis is about three years from the date of first recognition of the patient's aberration, but it varies between very widely different extremes. The shortest case personally observed by the writer was of apparently less than two months' duration; the longest, possibly eight or ten years. The preliminary stage may extend over years, while long remissions or periods of non-progression may lengthen out any stage of the disorder before the final general physical breakdown.

Diagnosis.—In the fully developed stage of paresis there is little difficulty in the diagnosis, particularly if the characteristic speech alterations and the peculiar facies which becomes familiar to all who have to do with these cases are present. It is in the earlier stage, when the physical symptoms are less developed, that the difficulty exists. The disorders that are then likely to be confused with it are neurasthenia—itself a protean affection—simple mania, and circular insanity. It is usually said that the moral deterioration as well as the actual mental deterioration is sufficient to distinguish the early stages of paresis from neurasthenia, but this is a hardly reliable test for all cases. There are incipient cases of paresis in which the moral and æsthetic sensibilities are not so obviously impaired, and cases of neurasthenia in which there are actual defects of memory and conditions of mental incapacity that might lead to error. It is not always possible to distinguish beyond question in the earliest beginnings the symptoms of the irreparable changes in the nerve cells from those of the less serious disorder. There is usually, however, a less serious aspect to the depression symptoms and a more gradual development in neurasthenia. The prior history aids in the diagnosis; in paresis the symptoms appear in a more sudden manner and in all cases time soon reveals unmistakable distinctive characters in the earlier physical symptoms, the abnormal pupillary reactions, the tremor and changes in the facial musculature, and the usually graver nature of the mental defect. Simple melancholic depression may sometimes be simulated for a short time, but simple maniacal excitation or hypomania, or still more the excited stage of circular insanity, is liable to cause mistakes. The type of mental derangements in some cases of hypomania and circular insanity is very similar to that of the exalted phase often observed in incipient paresis, and the circular type of the latter is sometimes even still more confusing. I have in mind a noted case of circular insanity who has been pronounced a paretic several times by alienists of experience. Here also the element of time aids in the diagnosis; the circular cases do not show the progressive dementia or the physical symptoms as they do even in the circular form of paresis.

The organic brain disease of arterial sclerosis or atheroma is another condition that has, in the writer's opinion, given rise to more erroneous diagnoses of paresis than any other. The clinical symptoms may closely resemble those of paretic dementia, using the term in its strictest literal sense. The transient congestive or convulsive attacks, the gradually advancing mental failure, the motor symptoms, and even the peculiar speech defect may to some degree be imitated, though the latter is seldom a perfect reproduction of paretic speech. The pupillary reflexes are also less characteristic, and the age and history of the patient usually clear up the diagnosis. Many cases of paresis in individuals over sixty years of age, however, have been reported, and I am inclined to think that most of them were really cases of senile organic dementia. Occasionally a case of this kind takes on the galloping form of acute delirium, thus rendering the resemblance more striking, and in most cases, though not in all, the prognosis is not much better than in true paresis.

Various toxic agents, alcohol, lead, arsenic, and the toxin of pellagra, now and then produce syndromes like that of paresis. It is possible, as already said, that there may be other toxins than that of syphilis that act as predisposing or even as direct exciting causes in exceptional cases. Possibly those mentioned may act in this way; the terminal paralysis in some cases of chronic alcoholism has sometimes a strong suggestion of the demented type of paresis, though there are characteristic differences. A temporary condition very closely resembling certain phases of paresis caused by this agent is well known. In some cases of chronic lead poisoning there is a close resemblance to paresis. Regis classes this among the pseudo-general paralyses, and finds it often only temporary and curable. It has, he says, a more rapid onset and course, and the symptoms, however severe, are apt to disappear with the elimination of the poison. Personally I have observed at least one case of chronic lead poisoning with some of the features of paresis, which was diagnosed as such by a skilled alienist. The patient died in a convulsive attack. The macroscopic appearances of his brain were not unlike those of paretics, and there was also an interstitial nephritis. So far as the diagnosis between this and the usual form is of any importance, it can be made as a rule by the history and the usual symptoms of plumbism.

Very much has been written in regard to the diagnosis between syphilitic pseudo-paresis and true general paralysis. It is said that the former can be distinguished by the irregularity of its course, the character of the ocular muscle palsies, differences of speech disturbance, and character of the delusions; the sensory symptoms, headache, etc., are said to differ; optic neuritis is early and acute; and, lastly, it is claimed that the syphilitic disease yields to specific medication which is ineffective in paresis. These are only some of the differentiating points

alleged to exist between them, but each different writer brings out new arguments in favor of the distinction between the two. So far as personal experience goes, the writer agrees with Berkley that in the present state of our knowledge a differential diagnosis between syphilitic disease of the cortex and paresis is often impossible. When, after recent syphilis, we have as far as possible the complete syndrome of paresis, and as resistant to specific treatment as is paresis, it seems to me useless to venture a distinction between the two. It is not necessary or even reasonable to assume that the toxin of recent syphilis may not affect the cortical neurons under favoring conditions so as to produce the disease that the same toxin favors after a lapse of years. Our experience does not warrant a belief that the element of time is in any way essential. True paresis coexists sometimes with tertiary or even with secondary syphilis, and a gumma of the base may be found simultaneously with the paretic changes in the convexity. Of course there may be a diffuse, cortical, brain syphilis that is not paresis, but when the clinical picture of the latter exists and the condition consistently follows its course, there is no reason for calling it anything else.

The other disorders commonly mentioned as liable to be confused with paresis, such as multiple sclerosis, cerebral tumor, etc., require but brief notice. In multiple sclerosis we have the intention tremor, the quite different character of the speech defect and gait, and the lack of characteristic mental symptoms of paresis. It is very rarely that a brain tumor alone presents features that would lead to a diagnosis of paresis.

The importance of the diagnosis of this disease is chiefly in its earlier stages, especially in the earliest or prodromal stage. This is not so much for the possibility of successful treatment, which is very remote at the best, but on account of the need of control of the patient before he can do harm by his extravagances, and occasionally this has a forensic importance. The paretic, in the incipient stage, may seriously involve himself or friends and may impose upon others to their disadvantage. It is advisable that insurance examiners, especially, should be posted on its earliest symptoms and indications.

Prognosis.—The outlook for a paretic is bad in all respects. Sooner or later, and generally within a few years after the recognition of his disorder, he succumbs either to one of the complications incident to his condition or finally to the exhaustion or marasmus of the final stage. A paretic's life is far more uncertain at any stage than is that of victims of most other forms of insanity, and there is no time when a sudden and fatal aggravation may not occur. Nevertheless, there are now and then instances of a stay or remission in the disorder, and sometimes even a marked improvement, so that the patient is able to return again for a time to his former associations and occupations. Cases of cure have even been reported, some of them probably based on these remissions. The characteristic of the disease, however, is its fatal progressiveness, and all reported cures should, as Kraepelin remarks, be looked on with suspicion. While it may be possible that cures have occurred, they are so rare as to make the probability of one in any given case altogether a negligible quantity. The disease may be set down, in the present state of our knowledge and therapeutic resources, as inevitably fatal.

Pathological Anatomy and Pathology.—In cases of paresis in which an autopsy is afforded in the early stage of the disease by deaths occurring from convulsive or congestive attacks or other accidents, the chief macroscopic appearances are those of a chronic meningo-encephalitis often modified to some extent by the immediate conditions preceding death. Thus, for example, if the patient has succumbed very early from convulsions, or especially if an attack of acute delirium has preceded death, the gross appearances of the brain may be more or less those of an acute meningo-encephalitis with foci of intense congestion and hemorrhages. Ordinarily, however, the appearances are characteristic: there is marked congestion of the membranes and cortex, often localized more prominently in one hemisphere and generally most marked in the anterior and middle regions of the convexity; there are distention and tortuosity of the pial vessels, the membrane itself is thickened and opalescent or milky, and the cortical substance in certain regions, especially along the median fissure anteriorly, is apt to be adherent to the membranes and these to the cranium, so that in removing the calvarium it is sometimes almost impossible to avoid tearing away portions of the brain over the summits of the convolutions. This is almost sure to occur in separating the pia-arachnoid. The dura itself is sometimes largely adherent to the inner cranial surface, and the Pacchionian granulations are often excessively developed. There may be subdural hemorrhagic foci or cysts, especially in cases that have lasted for some time with symptoms of the developed disease, and in advanced cases there is always a lessening of the volume of the cerebrum with atrophy of the convolutions, and the adhesions of the membranes and cortex are less noticeable. The cranium itself may be thickened in these older cases. The ventricles are liable to be dilated and often granular on the ependyma. The white matter of the centrum ovale is congested, dotted with minute bleeding vessels, the thickened walls of which can sometimes be felt like bristles on passing the finger over the freshly cut surface.

The brain atrophy, according to Mott's observations, affects particularly the frontal and central regions and the hemispheres rather than the basal portions and the cerebellum. In juvenile paretics he found the left hemisphere weighing less than the right, a fact which he thinks has a bearing on the theory of overuse or stress as an exciting cause of the disease. In paretics generally the region of the brain most subject to stress is that most often atrophied. Œdema of the brain is another common and striking feature in post-mortems of paretics.

The microscopic alterations in this disorder involve the membranes and all the cortical tissues, the nerve cells, the neuroglia, and the vessels of the brain, as well as the nerve fibres of the brain and cord and even the peripheral nerves. Together with the lesions of pachymeningitis and the leptomeningeal framework of the pia-arachnoid with the various attendant vascular alterations, there are still more important changes in the cortical substance itself. There are marked vascular inflammatory changes which in the acuter forms may be most intense. In these cases of galloping paresis not only the cortical but the basal finer arteries in the pons and elsewhere reveal a very marked periarteritis, the coats are thickened while the lumen is not decreased but is clogged with granular matter and débris of blood, while externally the lymph spaces are prominent and there are collections of granular cells clinging to the vascular walls and minute extravasations throughout the nerve substance. To a certain degree these appearances are characteristic of all comparatively recent cases of paresis, though not so marked as in the hyperacute form. In the older cases we have a decided increase of the blood-vessels, with thickened walls and occasionally minute aneurysms, relics of old microscopic hemorrhages, patches of softening, etc. It is in the nerve cells themselves, however, that the most significant changes are met with, though these may not be so prominent in the earliest stages of the disorder. Kraepelin mentions as the earliest appearance a swelling of the nerve cell in which the nucleus may also be involved, but Berkley says he has never met with this in the paretic brain. In the acute processes, according to the former authority, there is a rapid cell degeneration (liquefaction?), while in the more usual slowly progressive cases the process is more a gradual sclerosis of the cell substance. The cell body itself shrivels up, the processes become tangled, the nucleus as well as the cytoplasm atrophies, and in certain regions there is almost a complete destruction of nerve cells in the later stages. The degenerative changes are, in fact, localized to a large extent, and the pathological appearances described may be apparently absent in other cortical tracts, at least until the later period when the morbid changes have involved the brain generally.

The nerve fibres also suffer with the nerve cells, and in the later stages of the disease the degeneration may involve the greater part of these in extensive cortical regions and be traced down to the basal ganglia and the medulla. A peripheral neuritis in paresis has long been observed, and the spinal implication has been studied particularly of late years, especially with reference to the relations with tabes. These relations were noticed or suspected more than twenty years ago by Türck, Horn, Spitzka, Kiernan, and others, and their recognition has recently become quite general, especially since statistical studies have made evident the common specific etiology of the two disorders. It is probable that, as Fuerstner says, there are few cases of paresis without implication of the cord, but the fact that it has not heretofore been the general custom to examine it as carefully as the brain has prevented its being so universally recognized. In the tabetic cases the lesions may be those characteristic of tabes or primary degeneration of the posterior root fibres and posterior column sclerosis, but it is probable that in the majority of cases a descending degeneration of the pyramidal tracts will be found more prominent.

The neuroglia is also involved, there is proliferation of the spider cells, the processes of which form a tangled mesh, and in some portions, especially the internal and external limiting layers of the cortex, this is particularly noticeable, the more so from the more or less complete disappearance of the normal nerve cells in these parts. With this sclerosed condition the cortex is sometimes reduced to half its normal thickness. Every portion of the nervous system is liable to be affected in this disease, the changes varying according to the situation and the function of the part. Secondarily to the nervous lesions we have the possibility of any and every other organ being affected, and some of the important viscera are as a rule more or less involved. The kidneys are very commonly found disordered, there may be gastric or intestinal lesions and cardiac or pulmonary complications are common.

The question whether paresis is primarily a disease of the nerve cells itself or of the vascular system has been extensively argued in the past, and at the present time the weight of opinion seems to favor the view that in this disease, as in tabes, the primary lesion is in the degeneration of the neuron, that it is primarily a parenchymatous rather than an interstitial disorder, with secondary inflammatory conditions of the vessels and tissues generally. Berkley, however, among recent writers favors the theory of the primary vascular disease, and Chalmers Watson has recently argued for the same in tabes. Either view, however, is consistent with the toxic origin of these disorders; it is perfectly supposable that in the more acute and rapid forms the vascular involvement may be simultaneous with or locally precede that of the nerve substance, while in other cases, especially those of the late developing type, the damage to the neurons may have been primary. Assuming that the toxin is that of syphilis, as is probable, we know that it may lie latent in the organism for long periods, to be finally wakened into action by various exciting causes, or it may act violently on the nervous system very soon after its introduction into the body. Virchow's dictum, quoted by Mott, "that a cell nourishes itself and is not nourished," is, as the latter says, probably the key to the pathology of this disease; but this does not exclude the possible earlier action of a toxin on the vascular system than on the nerve elements in certain cases. It is permissible, however, to suppose, according to the latest evidence, that in the majority of cases of paresis the neurons weakened by toxic action give way under conditions of stress, waste exceeds repair, and the early symptoms are those of neurasthenia. Under the influences of a present poison, however, brain waste goes further, the degenerative processes give rise to waste products in the cerebrospinal fluid and blood, and, these being themselves toxic, react on the neuron structures by irritating and causing conditions tending to inflammation and lymphatic and venous stasis, arterial anæmia, and œdema. The circulation is thus rendered unstable, the cortical irritability is increased, and we thus have, besides the action of the original toxin, a continuous vicious circle of waste, production of toxic products—cholin, nucleo-proteid (Mott and Haliburton), these again reacting on the nerve element through the lymphatics and the blood. The various symptoms of paretic dementia can all be accounted for by this continuous and progressive intoxication and auto-intoxication of the brain.

In tabes the process is a similar one, and the relations of the two disorders are coming to be generally recognized. Their differences are essentially due to the different portions of the nervous system primarily involved—in paresis the cerebral association system and in tabes the exogenous afferent spinal neurons, as pointed out by Mott. The selective action of the luetic toxin is exhibited in both, and, as already noted, they not infrequently appear to be combined or to follow one another in the same individual. In each disease the parts first involved appear to be those subjected to special strains—in paresis the cortical neurons from worry, alcoholic or other excesses, overwork, etc.; in tabes the spinal sensory neurons from similar causes affecting the cord, the strain of special overwork or equilibrium, sexual excess, exposure, etc. In each we have the specific pupillary reactions, the meningeal thickening, interstitial sclerosis, and wasting of the neurons. The pathological resemblances are certainly close enough to suggest a relation between the two disorders, and, taken in connection with the known facts of their etiology and course, the belief in their essential identity is certainly strongly favored, if not absolutely confirmed.

Treatment.—Inasmuch as paresis is essentially an incurable disease, the treatment is mainly palliative. It may be that, could it be taken in its very beginnings, there might be some hope of cure; but the opportunity is seldom if ever afforded. Still if a course of iodides is well borne it is worth trying, and the writer has sometimes seen what he thought was temporary improvement from it. He has had less experience with the mercurial treatment, but it is strongly recommended by Berkley. In some cases, and in advanced stages in all, specific treatment is ill borne and should not be carried far. Various general remedies have from time to time been recommended, but none have won much confidence. A judicious use of hydrotherapy, baths, prolonged and otherwise, adapted to the case, and carefully administered and watching the effect, has been useful, and in some cases has apparently produced long remissions of the disease. Baths are of course an essential adjunct to the treatment, and strict cleanliness must be secured, especially in the demented conditions. Serum therapy has, of course, been suggested, and very recently Bruce has reported experiments with the injection of serum from cases in remission. The pathological theory on which this treatment is based—that paresis is an intoxication from the bacilli of the colon group (Ford Robertson)—will require a great deal of demonstration before it can be accepted, but as a therapeutic suggestion it should be mentioned. In any case, on general principles, it is advisable to protect the patient as much as possible from any effects of intestinal intoxication. Tonics, heart stimulants, hypnotics, local remedies for bedsores, etc., all will come into play, in the various stages of the disease, to meet occurring conditions. Drugs usually fail to do much good in the acute delirious attacks, but sedatives should be tried with due precautions. In the paretic status epilepticus injections of chloral or hypodermic medication may be tried.

It would be well if all incipient paretics could be put under a modified restraint; often a rest cure would seem advisable. When the disease has fairly manifested itself, asylum treatment is necessary and should be continuous except during pronounced remissions. If during these the patient is able to be at home, he should still be under medical surveillance and advice. In the closing scenes of the disease, the most that can be done is to meet the symptoms as they arise and make the patient's last days as decent and comfortable as possible. It is important,

it should be said, to watch the patient's eating, and give only such food as can be taken safely without danger of choking. The condition of the bowels and bladder and the trophic alterations will all require careful attention.

Henry M. Bannister.

XIII. INSANITY DEPENDENT ON CEREBRAL DISEASES.—The term organic insanity or that from gross disease of the brain is usually confined in classifications of mental disorders to derangements associated with existing arteriosclerotic or syphilitic conditions or with actual hemiplegia or tumor symptoms. Taken in its broader sense it would, of course, include other forms not usually thus designated, such as paresis, most if not all epileptic mental disorders, and also senile insanity due to the pathologic changes of old age in the brain. Here, however, the term is employed in its usual signification, meaning by it the psychic disorders accompanying apoplexies, neoplasms, general or local cerebral arteriosclerosis, traumatisms and syphilitic diseases of the brain. The distinction is rather an arbitrary one in some respects, but it has its convenience in affording a place for special consideration of a number of mental syndromes having a direct etiologic connection with certain lesions, and moreover often modified in their psychic manifestations by the character and extent of these lesions.

The distinction between insanity from arterial disease of the brain and from certain types of senile mental decay is not a very clear one, especially since the former occurs as a rule in the down-hill period of life and is attended with other more or less similar conditions of general bodily decay. It may often properly be counted as a rather more pronounced form than usual of senile insanity, differing from the usual type only in its more marked symptoms and its commonly earlier appearance. "That a man is as old as his arteries" is a wise medical saw, but in most cases the brain wasting from rigid arteries does not cause insanity, and senile dementia when it appears comes on in the later stages of life and in less pronounced a form than is the form here under consideration. There are, as we understand it, two conditions of non-specific arterial disease that may cause general mental disorder, viz., atheroma, a well-known form of degeneration, usually senile, but occasionally premature, often more or less localized, and arteriosclerosis, a more general condition, usually toxic in origin, of arterial thickening and sometimes of atrophy in which the brain involvement may be secondary to or associated with like arterial disease elsewhere in the organism and especially in the kidneys. Binzwanger and Alzheimer have described a type of insanity associated with this condition, which may simulate the dementia form of general paresis with its paretic disorders of speech and frequent circumscribed paralyses and partial or complete temporary remissions. It is hard to say that this is a constant or even approximately frequent type from this cause, but a general demented condition may be said to be the rule in the advanced cases. There are, however, cases of marked arterial disease, more especially perhaps of the atheromatous type, in which the mental symptoms have a wide range, including both depressed and exalted states and conditions of chronic persecutory delusional insanity. With these, however, occur signs of gross cerebral disease such as convulsions, temporary hemiplegia, or spastic symptoms, etc. It is questionable whether we can safely allege that any one common type of clinical syndrome prevails, other than the dementia shown in loss of memory, irritability, mental confusion, lack of emotional control, etc., that are characteristic of these cases, and which are liable to complicate whatever special form of mental disease the condition may simulate. Perhaps we should add the pseudo-paresis due to this type of arterial disease, which is not uncommon and is, in the opinion of the writer, probably responsible for most if not all cases of alleged paresis occurring after the ages of fifty-five or sixty. The resemblance to the demented type of paresis is close in many respects, the occasional convulsive or congestive attacks, the paresis, etc., all closely resemble the true paretic dementia. There are generally, however, according to my observation, other symptoms of general diffuse arteriosclerosis which are lacking in true paresis, the speech is less characteristic, the disease less rapidly progressive, the remissions are rarer, and a specific history and the Argyll-Robertson pupil are lacking. There is a peculiar general facies in genuine beginning paresis—not meaning merely the facial expression, but peculiar to cases in their earlier stages; later, when the paralysis and dementia are more advanced, there is more resemblance between the two. The terminal stages are much alike so far as the clinical symptoms are concerned. The prognosis of this form is usually bad, but occasional temporary derangement of almost any form may occur in connection with the local minute aneurisms or hemorrhages of diffuse or local arterial disease of the brain.

Multiple cerebro-spinal sclerosis, with its typical symptoms of intention tremor, rigidity, nystagmus, etc., may also be attended with mental symptoms; a certain amount of mental dulness is probably the rule. It is not so frequent, however, to see what can be called actual insanity from this cause, and when it occurs it usually takes the dementia type, above described.

Hemorrhages of the brain are not necessarily dependent upon any diseased condition of the arteries and may occur at any age, indeed their greatest frequency is between early maturity and old age. The same is true of embolism, thrombosis, and tumors, all of which may be attended with symptoms of decided mental alienation. We can group for convenience' sake these derangements, the first three together, or perhaps rather the first two as post-apoplectic insanity, while the symptoms of thrombosis are liable to be slower in their onset and therefore not so properly designated as due to a stroke or sudden ictus. So far as the mental symptoms are concerned, however, there is no practical difference and the term paralytic insanity would apply alike to all three. It is probable that in every case of severe hemiplegia there is left at least a slight degree of mental impairment, but this is not always perceptible, even to rather close observations after the slighter attacks. It is only in the minority that we have what we can call actual insanity and this when it occurs may be but temporary. Sometimes, even after a minute hemorrhage, there may be a temporary hallucinatory delirium, but this is not accounted as true insanity. The most frequent change observed is a certain degree of mental incapacity, shown in inability to follow successfully former occupations, and a lack of emotional control. This may be temporary but often it is permanent, and constitutes a mild form of organic dementia that may not be sufficiently pronounced or serious to disqualify altogether the subject from social and business life. The younger the patient, the less likely is this condition to be lasting; in the older cases in which the atheromatous changes of senility have begun and progressed to greater or less extent, the mental weakness is apt to be progressive and a marked true organic dementia occurs. In the later stages these old hemiplegic dements are often helpless untidy paralytics; sometimes, however, the mental disorder takes on the form of ordinary terminal dementia or what is called usually chronic mania or melancholia according as motor excitement or depression prevails. Aphasic and other complications are frequent and post-hemorrhagic choreic symptoms are occasionally met with. The vegetative functions may be comparatively unimpaired, except in so far as they are embarrassed by the patient's lack of care of himself or by his paralysis. These chronic cases usually end in death from some intercurrent affection or a recurring paralytic stroke; sometimes from general breakdown with bedsores, and other trophic symptoms such as local gangrenes, etc. Kidney and heart diseases are, of course, not infrequent complications aiding in the fatal outcome. Convulsions are not rare and have also their influence or rather their evil significance.

Other forms of insanity may follow apoplectic attacks; probably the most frequent type is a confusional delirium

or mania, such as that already mentioned, but much more pronounced and serious and underlaid by a very decided general mental impairment. It may be called an agitated dementia with hallucinations and illusions, often permanent, though remissions and exacerbations may irregularly occur. In other cases melancholic symptoms may prevail with self-accusations and decided suicidal tendencies. These are sometimes well developed when the depression is not so apparent, but this is not usually the case. Delusional insanity with ideas of persecution is also sometimes observed after these brain lesions, and I have observed cases in which these symptoms were the only very noticeable after-effect of the paralytic attack, the patient appearing to all but the closest observers and to those of his own family as very nearly in his normal mental condition.

Thrombotic dementias, which are claimed by Berkley to be the most frequent of all, usually take on the form already described when speaking of arteriosclerotic disease of the brain, in which, in fact, they most commonly occur. There are more apt to be premonitions, headaches, vertigos, temporary aphasias, and local paralyses, drowsiness, etc., before the development of the hemiplegia which may itself be gradual in its onset. The mental symptoms may also be gradual in their appearance, or rather there may be precursory phenomena such as impaired emotional control, some loss of memory, etc., before the paralysis and the associated fully developed aberration. It sometimes, therefore, is slightly different in this respect from the other post-paralytic derangements, but there is no essential difference in cases from this cause and it may also occasionally give rise to diverse clinical symptoms of maniacal excitement, depression, delusions, etc. The subjects of thrombotic softening and its mental complications are apt to be of more advanced age than those of post-paralytic insanity from hemorrhage or embolism, unless, as is often the case, there is a specific taint combined with excesses and overstrain in its etiology.

The *pathology* of insanity from arterial diseases in the brain is necessarily complex and various in details. We may include it, however, under one general head, viz., disturbances of nutrition of the nerve elements, whether through irregularities of blood supply, from vascular rigidity and non-responsiveness to the normal vaso-motor regulation, or to direct injury or cutting off of the circulation in hemorrhage or arterial occlusion by emboli or thrombosis. In post-mortems we find the characteristic vascular lesions of arteriosclerosis or premature atheroma, and in long-continued cases brain wasting, especially of the frontal lobes, thickening of the pia, adhesions of the membranes, excess of Pacchionian granulations, sometimes pachymeningitis, cysts, organized clots, etc. The lesions of acute softening or of acute hemorrhage need not here be detailed.

The *prognosis* of arteriosclerotic mental disorder is not good, though that from hemorrhage or limited thrombosis is somewhat less serious. The liability to recurrences of apoplectic attacks or of extension of areas involved must be reckoned with and an apparent recovery of insanity following such accidents not be estimated with any too sanguine temper. The underlying condition has also to be considered, viz., cardiac disease, heredity, and any toxic agency that may be or have been active. Probably the least unfavorable prognosis can be given when the mental symptoms are due to a not too extensive softening from embolism in a person of otherwise sound cerebral organization. Here there may be no extensive arterial involvement.

The *treatment* is mainly symptomatic: quiet so far as it can be secured, attention to nutrition and elimination, securing of sleep, regulation of the circulation, etc. If there exists any bodily condition that aggravates the mental symptoms or threatens to do so it must be attended to.

Among other marked gross cerebral conditions that give rise to insanity, syphilis takes perhaps the foremost place. The amount of literature on this subject is very extensive, and the existence of a special recognizable type of mental disorder due to syphilis seems to be taken for granted by many alienists. There is no question but that syphilis is an antecedent or cause of very many cases of insanity other than paretics, who are generally coming to be considered as usually owing their disorder primarily to this cause. It is another thing, however, to admit that these cases are generally or even often of such a character as to form a clinical species of syphilitic insanity. Many of the best authorities deny this, while acknowledging that the close association of the specific disease and the mental disorder may be apparent. Syphilis has so many possible deteriorating effects on the organism that it can turn the scale easily between mental health and disease in those predisposed to insanity even before it manifests its special effects on the nerve centres. Its usual mode of attack on the brain is apparently through the vascular system or by the disturbing action of the neoplastic growths. The possible suspicion of lues in cases of cerebral arteriosclerosis has been already referred to, and the clinical symptoms of specific and non-specific arterial brain disease are not, in the writer's opinion, sufficiently different to permit their distinction so far as the psychic manifestations are concerned. The elaborately tabulated differential diagnostic points also between cerebral syphilis and paresis have not, so far as his experience goes, been found entirely reliable, and any differential diagnostic data between the mental symptoms of cerebral syphilis and those from non-specific arterial disease are still less constant. Paresis is a well-marked species of insanity, but in some of its phases and especially in its later stages it is often closely simulated by the dementia from arteriosclerotic or atheromatous disease. When recent or existing syphilis is associated with a clinical syndrome throughout like that of paresis there is no good reason for calling it anything else, and aside from such cases there are no really well-defined characteristic types of mental derangement that can be called syphilitic insanity—that is, so far as the strictly psychic symptoms are concerned. Of course, the association with the physical symptoms of cerebral syphilis, such as the paralysis of special cranial nerves, etc., makes the etiology evident and to a certain extent justifies the use of the term. Without these or a history of specific disease there would be very insufficient evidence of the existence of any such form. The most common type of derangement met with, apparently due to lues, is a gradually progressive dementia, but any other of the forms of insanity caused by toxins acting on the neurons or by arterial degeneration may appear. It is only in those possible cases of syphilitic insanity in which the poison overwhelms the nerve elements before it has acted long enough to produce its effect through arterial disease that it is likely we can find any really characteristic conditions, and our acquaintance with such cases is as yet too limited to enable us reliably to enumerate such differentiating characters. There is also a specific psychic factor present in some cases of syphilis which can hardly be called syphilitic in itself, but which may be prominent in the mental symptoms; that is, the moral effect of the existence of the disease. This, I think, I have seen to color, so to speak, the mental conditions in one or two cases in which the symptoms were of the depressive type and the organic disease certainly slight.

The mental symptoms of cerebral syphilis as described by authors are mainly a progressive dementia with sometimes a moral deterioration as a prominent feature in the earlier manifestations. Sometimes there may be a maniacal outbreak of brief duration or suspicious delusions. A special feature described by some is the changeableness of the symptoms. Some patients are for the most part quiet and apathetic, but occasionally have short spells of excitement and occasionally short spells of lucidity, again relapsing into the condition of lethargic depression. All the elaborate descriptions of the clinical phases of mental disease from syphilis, however, do not cover anything that cannot be shown to occur in insanity from non-specific tumors or arterial disease or from the action

of other toxic agents on the brain. Epileptic insanity, from syphilis, is a well-known type.

The treatment of these cases of derangement from lues is that of the specific disease, with, of course, attention to the special symptoms of the patient's mental condition as they occur. The patient is primarily a syphilitic, and much good can be done to the physical health and occasionally also to the mental symptoms, though the prognosis in these cases is not particularly good. If no extensive organic changes have taken place and the case is largely a syphilophobic depression the prospect is often a hopeful one. These cases are, however, the exception.

Non-syphilitic brain tumors occasionally produce mental alienation and the type is often similar to that from specific disease—a gradually progressive dulness or dementia. They are, of course, not so liable to be multiple or to be associated with diffuse disease of the membranes and vessels, and aside from general pressure symptoms their location may affect the form of insanity. Tumors in the frontal lobes and corpus callosum are apparently most frequently attended with decided mental symptoms, though a certain degree of dulness and impairment may occur with them in other locations. Starr says that neoplasms in the base of the frontal lobes are not accompanied with these mental symptoms. This is not universally correct, for I have seen what was apparently a soft gliomatous growth involving this region and extending backward so as to involve the optic nerves and produce total blindness accompanied with a very profound dementia. In a very large proportion of cases of tumor there is not any positive insanity, though there may be some slight degree of dulness of perception, aphasia, somnolence, etc., and often there are no real mental symptoms whatever.

Abscess of the brain, apart from traumatism, is not commonly recognized as a cause of mental disorder. Acute abscess is, of course, often associated with meningitis and there are likely to be delirium and other symptoms of meningitis.

Traumatisms are a frequent cause of mental aberration both as an immediate and as a late result. A very large proportion of epileptic insanity is really due to this cause, but this type need not be here considered. The mental disorders from traumatism may take on various forms, some of them in no way characteristic of their cause, and for this reason some text-books contain no special chapters on this subject and do not include it in their classification. There are, however, certain mental symptoms frequently following severe injuries involving the brain, and the use of the term traumatic insanity is to a certain extent justified. The usual first result of a cerebral concussion, for example, is unconsciousness, which may last for from a few minutes to several hours or even for days, and be followed by either recovery after a period of hazy consciousness or by a confusional delirium that may in some cases be permanent or pass into a condition of dementia. In other cases there may be melancholic or maniacal symptoms or a dementia from the beginning. The more serious symptoms, of course, are likely to follow severe injuries involving the cranial bones, lacerating the cerebral substance and setting up suppurative processes in the brain by infection. A common immediate mental condition, according to my observation, has been a semi-dazed state in which the patient seemed unable to get rid of some besetting ideà often connected with the accident, and asked over and over again in regard to it, apparently immediately forgetting the replies received. Sometimes, and this is rather frequently the case, the patient appears to get over the immediate effects of the injury, but after a longer or shorter time secondary results begin to appear: cerebral symptoms, such as vertigo, tinnitus, cerebro-asthenic symptoms, incapacity for mental exertion, failure of memory and of attention, sometimes a peculiar obstinacy and wrong-headedness is noticeable, together with morbid impulses and moral deterioration. While in some cases it is hard to say that the patient is actually insane, it is very evident that he is not the same person as before.

This change may be progressive, ending in more or less pronounced dementia, or epilepsy may supervene—this last is perhaps as frequent an outcome of these cases as any other. The locality of the injury may affect the form of the mental change; it seems probable that moral deterioration and general change of character are most likely to be observed after injury of the frontal lobes and more noticeable because, when these are most involved, the physical symptoms of disorders of motor functions and sensation are less likely to overshadow them. There is also after brain injury, according to some authorities, a special weakness toward alcohol or drug habits; Macpherson says that a very large proportion of these cases of late-appearing traumatic insanity take to alcohol as a habit, and Kraepelin remarks on the peculiarities of these subjects toward alcohol. When the brain mischief has progressed sufficiently to produce decided mental symptoms long after the injury, it generally implies profound alterations and the prognosis is correspondingly unfavorable. The condition may not be a constant one, it may take on the remittent form, indicating a lesser degree of degeneration, but one hardly more encouraging as regards the final outcome. I can recall few if any cases of genuine traumatically caused insanity of the late-appearing type that made a permanent complete or even approximate recovery. The case is different with the derangements directly following injury; they may be only temporary, their course and outcome depending on whether there has been a lasting lesion set up, or one that so embarrasses intellectual and emotional functions as to cause functional arrest, or leads to functional perversion. We know that many serious injuries of the brain occur without doing this, but there is always a chance that even apparently slight injuries may be followed by serious consequences. Whatever the type of the insanity, whether dementia ranging from perceptible moral and mental weakness, to the complete form, or delusional or periodic maniacal attacks, the prognosis is alike dubious.

In many of what are considered ordinary cases of insanity from brain injuries, there is probably an epileptic element that can be determined only by close and prolonged observation. Something may be said here of the popular belief that occasionally brain traumatisms may improve an existing morbid mental condition. There is little if any reliable medical evidence of this, and all that can be said in its favor is that its impossibility has not been demonstrated. It is as rational to believe that an accidental traumatism might possibly relieve intracranial pressure as that an artificial one can do the same in Lannelongue's operation, but it must be a very rare and happy accident.

If insolation is, as some recent writers have held, an infectious febrile disease, it would not be correct to class mental disorders caused by it as traumatic insanity. It has nevertheless some of the characteristics; the frequent late appearance and the common occurrence of epilepsy are especially notable. In my personal experience, however, I have seen more cases of delusional insanity from this alleged cause than was the rule from other traumatic causes. It is probable that insolation is made accountable for some cases of insanity in which its action has been merely an incidental one, *e.g.*, in degenerates, etc., but there are undoubtedly cases in which it alone is responsible.

The most frequent psychic symptoms following sunstroke are said to be general weakness and incapacity for mental exertion without necessarily active derangement I have seen a number of cases of what might be called late-appearing paranoic insanity, and in one or two cases mania following the accident and credited to it after many months. Cases of terminal dementia from this alleged cause are not rare in asylums, the history of the original disorder being often lacking.

The treatment of traumatic insanity is necessarily largely symptomatic. Cases are reported of cures through surgical operations, and it is, of course, possible that comparatively recent cases dependent upon tangible

lesions may thus be relieved, but some at least of the popular stories of cures of long-standing dementia, etc., by trephining are most probably apocryphal. The cases of traumatic insanity of long duration that have come under the observation of the writer were generally hopeless as regards recovery. The liability of recurrence in apparently recovered cases must also be kept in mind; the association of traumatism with recurrent insanity is especially noted by Bevan Lewis.

Recent cases of mental disorder from traumatism should be treated like other recent insanities, keeping in mind the cause, and if there is any probability of betterment by surgical operation that can be safely resorted to the chance should be taken. *Henry M. Bannister.*

XIV. INSANITY OF THE NEUROSES.—The general neuroses, of which the most important to us are hysteria, epilepsy, neurasthenia, and chorea, should be considered from two standpoints, according as they affect previously healthy nervous systems, or as they develop in individuals whose nervous systems are unstable on account of hereditary taint. In the former they run their course without involving the mental processes, but in the latter some mental disturbance, however slight, will result. Notwithstanding the complexity and extreme diversity of the symptomatology of the psychoses dependent upon the neuroses, they have a common pathogenic basis, but the degree of mental disturbance, with ensuing deterioration, does not bear any relation to the severity of the antecedent neurotic condition.

HYSTERICAL INSANITY.—Hysterical insanity is a psychoneurosis which is characterized by the ease and rapidity with which psychic disturbances appear and disappear in connection with physical disorders, such as anæsthesias, paræsthesias, paralyses, convulsions, and anomalies of secretion, without marked intellectual disturbance.

Etiology.—Hysteria develops upon a morbid constitutional basis, defective heredity occurring in seventy to eighty per cent. of cases. Women are more often attacked than men. Defective training and education are important causative factors. Mental stigmata, such as irritability, indolence, waywardness, and sudden emotional changes, are often recognized in early life. Chorea, headache, defective speech, and other disorders have sometimes been noticed. Uterine disease is undoubtedly a potent factor, but the rôle played by the disturbance of the female sexual organs is not clear. The nature of hysteria is still obscure. The best explanation is offered by Möbius, who characterizes hysteria as "a congenital morbid mental state where diseased bodily conditions are produced by ideas," which are strongly emotional and sometimes of indefinite content.

Symptoms.—The symptoms of hysterical insanity are psychical and physical. The psychical are those continuously present during the interparoxysmal period, while the dreamy states characteristic of the crises or attacks, appear only in the paroxysmal periods.

Psychical Symptoms. Patients are usually deficient in intellect, although sometimes well endowed as regards artistic attainments. They apprehend clearly and observe correctly their environment, especially its defects. Judgment is always impaired, although patients may appear bright and vivacious. They are attracted by anything new, adopt peculiarities in dress, become zealous adherents of various religious sects, and keenly enjoy anything sensational. Their memory is retentive and perception unimpaired, but they are prone to misrepresent, amplify, fabricate, crave sympathy, and create sensations.

The mental life is largely controlled by the emotions, which are subject to frequent and abrupt changes. Emotional instability and lack of self-control are shown by sentimentality, irritability, capriciousness, and frequent alterations of mood, which at one time is joyous, and the next tearful. The intense egotism and ever-wakeful self-consciousness are characteristic, and are often associated with a morbid introspection, which induces a continual watching of the mental and physical processes. Thoughts of self dominate, and no attention is paid to the interests of others. Trifling discomforts receive exaggerated attention, and painful sensations linger long after the removal of the cause. The whole life seems to centre about their disease. They become fond of invalidism, consult numerous physicians to whom they minutely detail their symptoms, and are ready to adopt any new method of treatment, even if attended by considerable suffering. A certain class of patients are continually tormented by terrible thoughts, ungrounded fears, frightful dreams, alleged hallucinations, etc. Threats and sometimes melodramatic attempts at suicide are made, such as tying a ribbon about the neck, jumping into shallow water, etc.

The enfeeblement of the will may be shown by increased susceptibility to external influences. Ordinary acts, such as speaking, writing, walking, eating, etc., become difficult, and may render the patient unfit for the ordinary avocations of life. Patients are often obstinate in their adherence to demoralizing influences, occasionally subjecting themselves to pain and great discomfort for insufficient reasons, even refusing to speak or take nourishment. Their conduct accords with their prevailing mental state, and is unstable and erratic. A longing for adventure and a desire to pose are characteristic. Some are frank and vivacious in manner, others reserved and bashful, or silly and sentimental. They have little disposition for earnest work, lack perseverance, become easily exhausted, and always spare themselves. On the other hand, they spend much time with trifles, arranging and rearranging bric-a-brac and dilly-dallying with their toilet. The vehemence of the patient's expression does not correspond to the intensity of the emotions, as it is not unusual to witness copious weeping, or even fainting during the recital of sufferings which have no existence except in the vivid imagination of the patient.

These mental symptoms merely give a general clinical picture of hysterical insanity, but each case presents distinct peculiarities and should be studied individually.

Physical Symptoms. The physical symptoms of hysterical insanity are more conspicuous, and are generally regarded as more important than the mental. They consist of certain functional disturbances, such as paralyses of different limbs, choreiform movements, contractures, localized and general convulsions, aphonia, impairment of speech, numerous sensory disturbances, including paræsthesias, anæsthesias, hyperæsthesias, various visual disorders, globus, clavus, singultus, fainting spells, loss of appetite, obstinate vomiting, and disturbance and anomalies of secretion. These are dependent in appearance, persistence, and departure upon psychic influence, and do not follow any anatomical or physiological rules. Convulsive movements, or hemicrania, can often be made to disappear by pressure upon the eyeballs. An unexpected dash of cold water upon the face, or firm pressure over the ovaries or hypogastric region, often causes the disappearance of paralyses and contractures. Bedridden patients can sometimes be rapidly aroused by a sharp command, new environment, or as a result of some sudden freak. The transformation is, however, generally of brief duration, and even still more distressing symptoms than the former may return.

A prominent feature is the disappearance of the symptoms when the patients believe themselves unobserved, and the reappearance of the same when their illness is referred to or when confronted by a physician. Further attempts at dissimulation are observed in efforts to produce ulcers, pricking the gums to make bloody sputa, or secretly removing fæces to convince the physician that the bowels are occluded, etc.

Psychic Disturbances.—Of the transitory psychic disturbances, the dreamy states are the most prominent. They are characterized by marked clouding of consciousness, which may either follow, take the place of, terminate in, or be interrupted by an hysterical convulsion. The patients lie quietly with relaxed limbs, occasionally showing slight rigidity, breathing quietly, with slow pulse rate, and the eyes turned upward or rotated late-

rally. They are irresponsive, except to a powerful stimulus, which sometimes entirely arouses them. Such a condition may last for from a few hours to weeks, and is only interrupted by occasional convulsions and short lucid intervals, during which food may be taken. Sometimes the dreamy state simulates ordinary or profound sleep, with deep and regular respiration, but is usually of short duration, with gradual awakening, and no recollection of the disorder. Somnambulism may be considered a phase of the dreamy state, and may occur during the natural sleep of hysterical patients or during the daytime, either independently or in connection with a convulsive attack or fits of laughing or crying. Another form of dreamy state appears in connection with the delirious excitement of a severe hysterical attack. Consciousness is markedly clouded, and there are many hallucinations. Ecstatic mystical visions are seen or frightful ordeals experienced. The dominating emotional state is indicated by the manner and expression.

Younger patients present still another form of the dreamy state, in which the clouding of consciousness is moderate and does not prevent the recognition of their environment. They usually exhibit a happy, unrestrained mood, occasionally with marked silly behavior. All sorts of foolish pranks are performed, such as the imitation of cries and behavior of animals, screaming, etc. The morbid characteristic of this apparently conscious behavior is emphasized when, as occasionally happens, it terminates in a light convulsive seizure, followed by a brief period of depression, with no remembrance of antecedent events.

The memory of events prior to and during these different dreamy states is always much confused, and sometimes completely abolished. Some cases present a sort of dual personality. Sometimes during an attack a particular period of a patient's life is lived over again. Such alterations of personality arise only under the influence of auto-suggestion.

There still remain to be mentioned certain mental disturbances of brief duration, which are characterized by a gloomy and anxious mood, sometimes accompanied by delusions of self-accusation and indefinite hallucinations. Conditions of excitement arising as the result of jealousy, spite, and the like, more frequently appear in the form of passionate outbreaks with violent abuse, although sometimes accompanied by a tendency to destructiveness. They usually pass off in a few hours.

The course of hysterical insanity is usually protracted, extending over many years, during which the individual symptoms may show the most varied changes.

Diagnosis.—The diagnosis is far more difficult in hysteria in the male, and especially in differentiating the insanity of degeneracy. In the degenerate state the course is more uniform, and the dreamy states and various physical symptoms are absent. The differentiation from epilepsy is considered under that disease, but it is necessary to differentiate the dreamy states of hysteria from those of epilepsy. In the dreamy states of hysteria the behavior is quiet and the emotional disturbance slight, while in epilepsy there are great irritability, fear, and frequently violence. In the interparoxysmal periods the hysterical patient usually displays rapid emotional changes, and the symptoms depend upon external influences, while in epilepsy the characteristic irascibility, violence, and evidences of mental impairment are dependent upon the seizures.

Prognosis.—While the prospects are good for the disappearance of the several attacks, it is not favorable for the future of the patient, who is apt to suffer from a recurrence of the same or other hysterical symptoms. Remarkable temporary cures are sometimes effected by the removal of prominent exciting causes, such as disease of the sexual organs, defective manner of living, etc. Hysteria in the male, with hypochondriacal complaints, is resistive to all modes of treatment.

Treatment.—The element most essential to the successful treatment of the disease lies in the personality of the physician, who must inspire the patient with confidence. Isolation of the patient is essential, except in the lighter forms of the disease, and can best be effected in a small sanatorium under the direct supervision of a physician, although the same object may be accomplished at home by the aid of an efficient nurse. Under any circumstances the patient should be given over entirely into the hands of the physician, who is then in a position to bring about great improvement, and often recovery, by the use of simple remedies. Careful physical examination should, of course, be made of each patient, and a general tonic regimen prescribed if necessary. Of the mechanical measures for the treatment of hysteria, the most important are hydrotherapy, electricity, massage, exercise, and employment.

There are various methods of applying water, but the best results are probably obtained by the use of the douche and spray, drip sheet, and by ablution or plunge. Collins regards the tonic bath as best adapted to the treatment of hysteria. In the use of the bath hysterogenetic zones should be protected, in order to avoid inducing an attack of hysteria, and reaction should be facilitated by passive movements, walking, or light gymnastics, continued for twenty or thirty minutes after the bath. It is, of course, desirable where possible to avail one's self of the facilities afforded by a hydriatic institution, but the same treatment can be accomplished at home with water under sufficiently high pressure, by the use of a detachable hose and tube. The faradic current affords the best method of applying electricity, and is frequently of service in improving the nutrition and relieving the anæsthesia and hyperæsthesia. The daily routine should, in addition, include rest and relaxation, with proper exercise, the latter best secured by massage, gymnastics, and out-of-door exercise. Disease of the genital organs may require surgical interference. Removal of diseased or even normal ovaries has been followed by improvement, but such drastic procedures are now generally regarded as unwarranted and of more detriment than benefit. Hypnotism is of value, but it should be borne in mind that its use is apt to establish an undesirable dependency of the patient upon the physician. In mild cases suggestive therapeutics is of value in overcoming individual hysterical symptoms, such as paralyses, sensory disturbances, and tremor. In the treatment of hysterical attacks, the patient can be restored to clear consciousness by a brisk command, or, if this fails, by a dash of cold water upon the face, the use of the electric brush, or pressure upon the ovaries or upon the hysterogenetic zones. Inhalation of chloroform may be necessary in some exceptionally severe cases.

Epileptic Insanity.—Epileptic insanity is a form of mental derangement accompanying epilepsy, characterized by a varying degree of mental deterioration, evidenced by emotional instability, impulsiveness, moral perversion, and impairment of the intellect and memory, with incapacity for production. It also includes certain periodical disturbances, denominated transitory ill-humor and dreamy states. The mental disturbances, however, which occur in epilepsy present great differences. Some individuals suffer from distinct epileptic attacks, and in the intervals do not exhibit the least mental abnormality, although as a rule the neurosis induces more or less mental impairment. Milder conditions of irritability and mental weakness may not be very striking, yet they are apt to pass into severe mental disorders.

Etiology.—Defective heredity is the most frequent cause of epilepsy, appearing in eighty-seven per cent. of cases in which a complete family history was obtained, while in over twenty-five per cent. epilepsy had existed in the parents. Alcoholism is another potent causative factor. Neumann states that in nearly twenty-four per cent. of cases one or both parents had been addicted to the excessive use of alcohol. The abuse of alcohol as a cause of epilepsy is evidenced by the frequency with which it appears in chronic alcoholism, and the great intolerance to its use manifested by epileptics. Various physical stigmata, evidences of congenital defect, such as malformation of the skull, microcephaly, hydrocephalus, etc.,

should not be regarded as actual causes, but rather as excitants of convulsions. In a certain number of cases a direct relation may be traced between head injuries and epilepsy, but the numerous scars so frequently found upon the head are more frequently the results than the causes of the malady. It is not uncommon for epilepsy to develop at puberty, at the period of involution, and in senility.

Pathology.—As all epileptics are not insane, the pathology of epileptic insanity must be based upon the seizures plus the heredity, including constitutional defects, and other factors with whose nature and influence we are not sufficiently acquainted. Probably the most important anatomical changes found in the epileptic brain are the increase of neuroglia tissue, especially in the superficial layer of the cortex, and sometimes in isolated foci, and sclerosis of the cornu ammonis. The consensus of opinion points to a toxic condition arising from faulty metabolism as the cause of the periodicity of the seizures, and the tendency of the nervous system periodically to react to any continued irritation, the convulsions being immediately due to the deleterious substance found in the blood. Epilepsies, however, due to brain lesions, cannot be explained on this toxic basis.

Symptoms.—Epilepsy may exist for years without obvious mental impairment, but in a majority of cases intellectual activity is impaired, though in a much less degree than the emotions and volitions.

All cases of epileptic insanity usually present more or less pronounced intellectual, moral, and emotional disturbance. Apprehension, however, is fairly keen, orientation normal, consciousness generally clear, but attention is usually impaired.

Hallucinations are infrequent, except in the dreamy states. When present they are generally of a religious character. Illusions frequently occur for a short time before and after attacks of grand mal.

Delusions are uncommon except in the dreamy states, when they are either accompanied by, or dependent upon, auditory and visual hallucinations, and are almost invariably of an ecstatic or terrifying character.

Ideation is limited, and there is a strong tendency in conversation to detail and circumstantiality. Essential points in narratives are obscured by a multitude of data and irrelevant and unessential accessories. Connection usually is not lost, but the aim is attained by circuitous paths.

Judgment is impaired, the degree depending upon the amount of mental deterioration. The true relation of ideas is obscured or even lost, and the most senseless and fantastic schemes are frequently devised, with inability to recognize the incongruity between the plans and the limited ability. Epileptics generally, however, have some insight into their condition, and recognize in a measure the nature of their disabilities. A few deny seizures.

Memory is always more or less impaired. Prominent events frequently repeated may be recalled, but events, whether recent or remote, connected with the general course of life, are more or less indistinct and hazy.

The narrowness of thought, due principally to faulty memory, naturally leads to a great prominence of self, especially noticeable in the conversation of epileptics. Another striking symptom is the religious content of thought, resulting in the quoting of Scripture, engaging in prayer, exhorting associates, reading the Bible, etc. Many are curious and meddlesome, and continually interfering with others.

The majority of epileptics show great emotional variations, but ordinarily they present a state of emotional indifference. Increased irritability, however, usually exists, and is manifested just before or after a seizure by frequent outbreaks of excitement, and alternations from elation to depression, or the reverse. Sudden uncontrollable impulses are frequent and characteristic symptoms of epileptic insanity. Assaults are made with or without provocation, and severe and dangerous injuries inflicted. Homicidal acts are not infrequent, but suicidal impulses are rare.

Apart from morbid impulses, the conduct is usually good. The ordinary proprieties of life are observed unless deterioration is profound.

Epileptics as a class have but little or no initiative, but if carefully directed are capable of doing routine work. But little capacity is shown where the higher grades of mental and physical training are requisite.

The seizures are the most important physical symptoms in epileptic insanity, and may assume the type of grand or petit mal. The former may be preceded by an aura, followed by a cry, a fall, and tonic followed by clonic convulsions, usually localized at first, but rapidly becoming general. During the convulsions, which may last from two to ten minutes, consciousness is lost, but gradually returns within a period of a few minutes to several hours. Twenty to several hundred attacks of grand mal may occur in status epilepticus without restoration of consciousness. In petit mal there is a transitory loss of consciousness, either with or without slight convulsive movements, usually lasting one or two seconds. The reflexes are abolished during the convulsions, and in some cases are not restored for some hours.

The speech of epileptics is often drawling, jerky, or strongly accented. Organic and functional disease of the heart is quite frequent, and the pulse rate is often increased.

The following mental states are recognized on an epileptic basis: 1. Transitory Ill Humor. 2. Dreamy States, in which are included Pre- and Post-Epileptic Insanity, Epileptic Stupor, Anxious Delirium, Conscious Delirium, and Dipsomania.

1. Transitory Ill-Humor. This form is characterized by the extraordinary resemblance which the separate attacks bear to each other, presenting the same recurring complaints, delusions, and impulses. The attacks are of varying intensity, and often come on in the morning. Patients awake peevish, faultfinding, irritable, threatening, and quarrelsome, often commit unprovoked assaults, break glass, destroy furniture, and use profane and obscene language. Occasionally they display vague hallucinations and express persecutory delusions. These attacks usually occur after a seizure, but may precede it, the convulsions generally clearing the mental atmosphere. The average duration is a few hours, but may persist a week or more. Amendment is gradual, and is followed by a striking feeling of well-being.

2. Dreamy States. The essential feature characterizing this form of mental disorder is the more or less profound clouding of consciousness. Transitory ill-humor often precedes these dreamy states, and there is no sharp line of demarkation between the two.

Pre-Epileptic Insanity often presents all sorts of morbid sensory impressions, such as flashes of light, impairment of vision, indefinite or strange sounds, peculiar odors, paræsthesias, etc. There may be associated fixed ideas, mistaken identifications, monotonous repetitions of words or phrases, involuntary or grotesque movements, and imperative impulses to strike, kill, destroy articles, etc. In a short time consciousness becomes more and more clouded, and the convulsions begin, terminating in a stuporous condition, lasting for hours or days.

Post-Epileptic Insanity is more common than the former and is characterized by a deep dazedness lasting for hours or even days. Difficulty of comprehension, confused speech, partial or complete disorientation, aimless wanderings, collecting of rubbish, and drinking of urine are often prominent symptoms. Sensory disturbances are undoubtedly present, but cannot be ascertained from the patient on account of the complete amnesia. The normal mental and emotional attitude is generally gradually regained.

Psychic Epilepsy. Mental and emotional disturbances characterized by suddenness of onset and marked clouding of consciousness, occurring in place of, or following, a seizure, are denominated psychic equivalents. These conditions generally come on without warning, and are more liable to occur in patients who have seizures at long intervals. The essential feature is the disturbance

of consciousness. Patients are confused, move and act in a mechanical or automatic manner, and often present evidences of illusions, hallucinations, and delusions. They wander aimlessly about, do not appear to recognize any one, and reply incoherently to questions. Fixed and peculiar positions are sometimes assumed, and occasionally there is heightened excitement or gloomy stupor, during which they expose their person, masturbate openly and shamelessly, and attempt sexual assaults. Some cases of somnambulism occurring in epileptics should be regarded as a form of psychic epilepsy. The numerous criminal acts committed during these periods demonstrate the extreme importance of the recognition of psychic equivalents.

The history of previous attacks of grand or petit mal, the absence of motive or attempt at concealment, and either the complete amnesia, or hazy recollection, of what has happened should render the diagnosis clear.

Epileptic Stupor. In epileptic stupor the clouding of consciousness is often extreme and prolonged. It usually lasts one or two weeks, but may last much longer. Patients may eat, speak, or perform certain mechanical movements, but without clear understanding. The same attitude is maintained for hours or even days, and the expression justifies the inference that the emotional sphere is dominated by confused terrorizing delusions, although sometimes the demeanor indicates happiness, or religious ecstasy. Patients are often indifferent, unresponsive, remain in bed, and soil themselves. Sometimes active resistance is shown if they are disturbed, and impulsive attacks and suicidal attempts are not infrequent. Sensibility is blunted, reflexes are abolished, and sometimes a temporary catalepsy is seen. Food is either wholly or partially refused. Recollection of the events is largely or completely lost. Restoration is generally gradual.

Anxious Delirium is more frequent than stupor, and may occur independently of the convulsive seizures. It develops suddenly, varies in duration from a few hours to two weeks, and is often preceded by fixed and recurring hallucinations. Orientation is lost, apprehension clouded, and hallucinations and delusions are usually of a terrifying character. Patients assert that they must be punished, have committed murder, are surrounded by devils, etc. They wade in blood, their parents are perishing, everything is being blown into atoms, etc. Sometimes God and Christ appear, and carry them in splendid chariots to heaven, but ecstatic feelings are transitory, and the dominating ideas are those of dread and fear. Some patients commit brutal and almost incredible outrages, while others try to run away to escape horrors and dangers which confront them. Consciousness is generally gradually restored, but sometimes clears up suddenly after a prolonged sleep.

Conscious Delirium is a rare form, which either follows a seizure or appears as a psychic equivalent. Patients appear conscious, but apprehension is greatly clouded. Answers to simple questions are coherent and relevant, but close observation reveals confusion and disorientation. The disposition is irritable, usually anxious, but sometimes elated, and delusional ideas lead to impulsive acts. Crimes such as arson, theft, desertion, and sexual assaults are committed, with apparent unclouded consciousness, but without insight into their significance. The attacks may last weeks or even months, or frequent attacks may occur at brief intervals.

Dipsomania. Alcohol is a frequent cause of epilepsy, and often arouses a latent epileptic endowment. Dipsomania resembles epilepsy in many ways, inasmuch as there is a paroxysmal impulse to the senseless abuse of spirituous liquors. Attacks begin with symptoms resembling periodical epileptic distemper. There are uneasiness, anxiety, despondency, irritability, anorexia, insomnia, and sometimes sexual excitement, accompanied by an apparently irresistible impulse to quiet morbid sensations by indulgence in alcoholic stimulants. Notwithstanding the large quantities of alcohol ingested, complete drunkenness is rare. After a longer or shorter period, drinking is suddenly discontinued, and is often followed by nausea, vomiting, catarrhal gastritis, unsteady movements, and tremor. Occasionally delirium and hallucinations supervene. Only a hazy recollection is generally retained of the debauch, and there is often deep contrition, with abhorrence and abstinence from alcohol until the next outbreak.

Diagnosis.—The occurrence of the characteristic convulsions generally renders the diagnosis of epileptic mental disturbance easy, but epileptic insanity should be differentiated from hysteria, dementia paralytica, and the katatonic form of dementia præcox.

In hysterical insanity there is more diversity in the development of the seizures, which are more frequently induced by external influences than in epilepsy. Consciousness is never wholly abolished, and sudden involuntary falls, with serious injuries and biting of the tongue, are almost never seen.

Dementia paralytica sometimes begins with epileptiform seizures, but other symptoms, such as impaired pupillary reflex, characteristic speech disturbance, ataxia, inco-ordination, etc., clear up the diagnosis.

The epileptic dreamy state may be mistaken for katatonia. In the latter we find negativism, muscular tension, passive resistance, correct execution of commands, mutism, stereotypy, with less disturbance of perception and orientation. In epilepsy there is anxious resistance with indifference to orders, associated with frequent assaults, atrocities, etc.

Prognosis.—The prognosis of epileptic insanity depends essentially upon its cause and time of onset. Pure epilepsy may disappear spontaneously. Epilepsy dependent upon gross brain lesion is incurable. When following head injuries some recoveries have been recorded. Improvement rarely occurs in cases in which attacks of stupor or dreamy states have occurred. In epilepsy developing late in life the outlook is very unfavorable. In alcoholic epilepsy treatment often results in cure or great improvement. As regards life, Dr. Worcester has found that sixty per cent. of epileptics die as a result of their seizures.

Treatment.—In cases in which there are undoubted cranial injuries or focal diseases, surgical interference is demanded. The results are generally unsatisfactory, although long-continued improvement has resulted from simple ventilation of the brain by trephining. Sources of reflex irritation, such as nasal polypi, decayed teeth, ingrowing toe nails, phimosis, paraphimosis, etc., should be removed. Careful attention should be paid to the alimentary system and the diet. The latter should be nutritious, but the excessive use of meat is to be avoided. As every epileptic is more or less intolerant of alcohol, complete abstinence is essential. While innumerable remedies have been used in the treatment of epilepsy, no drug exerts so powerful an influence over convulsive attacks as the bromide of potassium, or combinations of bromine with sodium or ammonium. The former may be given combined with small doses of Fowler's solution for long periods of time without inducing bromism or producing the troublesome acne. Some patients are intolerant of its use, becoming more irritable and quarrelsome; others are reduced to a stuporous condition, resulting in rapidly increasing mental deterioration. Prolonged experience is requisite to select cases suitable for protracted bromide treatment, as each case must be judged individually, but it should be tried in all cases.

When status epilepticus occurs, compression of carotids should be tried, and the administration of chloral hydrate and bromides by enema.

Chorea Insaniens.—Although psychical disturbance is rarely absent in chorea, fortunately in the majority of cases it is very slight, and consists principally of disturbances of memory and attention and of emotional instability, evidenced by irritability, peevishness, and depression.

In chorea insaniens these psychic defects increase until a real psychosis is developed. The subjects are usually young females at the age of puberty, although the disease may occur as the result of pregnancy. The mental symptoms may precede the choreic movements, but they usually occur after the motor phenomena have become

intense and violent. Commonly the case begins as one of ordinary chorea, with sudden development of the special symptoms. Within a short time the choreic movements become general, violent, and almost incessant, and active delirium speedily develops. In a less aggravated form of the disease a delusional condition is developed, with extreme loquaciousness. Fever is generally but not invariably an accompaniment, and the temperature sometimes reaches 107° F. Cases accompanied by high temperature usually terminate fatally. The excitement generally subsides in a week or two, and is followed by dulness and apathy, and sometimes by persistent delusions. Nourishment has often to be administered by the rectum or by a feeding tube, and stools and urine are commonly passed unnoticed. This condition slowly passes away, but may last weeks or months after the chorea has ceased, and it may be permanent.

Pathology.—The disease is probably due either to the absorption of septic material or to a toxin. Meningitis or vascular changes in the brain, and endocarditis have been found in the few autopsies recorded.

Diagnosis.—The violence of the choreic manifestations and the character of the mental symptoms should be sufficient to differentiate it from other forms of chorea.

Prognosis.—Osler stigmatizes chorea insaniens as a "terrible affection." Over forty per cent. of the cases terminate fatally.

Treatment consists in maintaining nutrition, securing rest, quieting excitement by hypnotics, and the prevention of injuries by the use of a padded bed.

Hereditary Chorea.—(Synonyms: Huntington's Chorea, Adult Chorea, and Chronic Progressive Chorea.)

Although this affection was described as early as 1842, and later in 1863, the first paper to attract the attention of the medical profession was written by Dr. George Huntington, of New York, in 1872, by whose name it is commonly known.

This disease is a comparatively rare one, and affects both sexes equally. It generally occurs between the ages of thirty-five and forty, although it may occur sooner or later. Cases, however, are infrequent before thirty and after forty-five. Generally there is a history of the disease in the preceding generation, but if a member of the family is spared, his or her descendants are usually exempt from the disease.

A striking feature is that of the motor phenomena, which differ from the movements in Sydenham's chorea, inasmuch as they are slower and more inco-ordinate, and lack the brusk, quick, and jerking character. The movements at first are of slight intensity, and are limited to a few groups of muscles, but they gradually increase in intensity and extent, and finally become general, involving the upper and lower extremities, trunk, and facial muscles. Speech and deglutition are affected, and the gait is characteristic, presenting constant variations, consisting of erratic, dancing, swaggering, and precipitate movements, during which the patient almost falls, before he recovers himself. In the early stages of the disease there is some ability to control the movements and perform voluntary acts, but in the later stages efforts to control the movements result in still more violent contortions. Sensation is unaffected, but there are increased myotatic irritability and sometimes ankle clonus. Patients rarely complain of fatigue, despite the incessant and violent movements, but finally take refuge in bed, sometimes before the ability to walk is lost.

Mental disturbance is an invariable accompaniment, generally occurring in the terminal stages of the disease, but cases occur in which the mental symptoms precede the choreic manifestations. An analysis of the mental symptoms of the nine cases under observation at the Connecticut Hospital for Insane gave the following results: Three of the patients manifested mental symptoms similar to the expansive form of general paresis, presenting a condition of gradually increasing cloudiness of consciousness, partial disorientation, general sense of well-being, irritability with restlessness and sometimes violence, but with generally a happy and contented disposition, associated with delusions of wealth and power. Two were anxious, fretful, and aggressive, with moderate excitement at irregular intervals. Their delusions were of a persecutory character, with a rather sad and anxious disposition, tinged with expansiveness. Consciousness was clear and orientation undisturbed at first, but they rapidly became demented, presenting complete disorientation, planless activity with occasional irritability, clouded consciousness, and extremely limited powers of comprehension. Two others were suspicious and apprehensive, exhibiting well-marked anxious depression, with persecutory ideas and pronounced suicidal impulses. Consciousness was clear and orientation preserved in both of these cases for many years, and they became demented very slowly. The two remaining cases presented symptoms similar to those of the hebephrenic form of dementia præcox, manifesting a marked change of disposition at the onset, evidenced by shyness, sullenness, and irritability, followed by depression, with hallucinations of sight and hearing and delusions of a depressive character. Clear consciousness and coherence of thought were maintained for some months, but both deteriorated rapidly, presenting poor attention, defective judgment, increased sexual desires, and heightened self-feeling, followed later on by indifference, apathy, and stupidity. All eventually terminated in progressive motor and mental enfeeblement.

Pathology.—Oppenheim considers the essential pathology to be miliary encephalitis, cortical and subcortical, followed by atrophy of the cortex. Clarke summarized his findings in two autopsies as follows: "Widespread but partial degeneration of the cells of the cerebral cortex, especially of the second and third layers, most marked in the frontal and motor convolutions, together with an increased amount of interstitial tissue and number of neuroglia cells." Autopsies of three cases at the Connecticut Hospital for the Insane gave similar diffuse lesions in the cerebral cortex.

Diagnosis.—The disease is, of course, easily recognized when it is hereditary, but its recognition is difficult in cases without this peculiarity. The age at onset, increased knee-jerks, characteristic gait, progressive character of the disease, with the obvious mental deterioration, are generally sufficient to differentiate it from ordinary chorea.

Prognosis.—Hereditary chorea is an incurable disease, and patients ultimately become bedridden. It lasts from ten to thirty years, and the progress is toward motor and mental, enfeeblement. Death usually occurs from some intercurrent affection.

Treatment.—Nothing has thus far been found of any value in the treatment of the disease.

William E. Fisher.

XV. INSANITY: DEMENTIA PRÆCOX.—(Synonyms: Insanity of Pubescence, Insanity of Puberty and Adolescence, Hebephrenia, *Idiotisme, Folie de la Puberté, Demence Précoce des Jeunes Gens.*)

Descriptive Definition.—Dementia præcox is a developmental disease of the mind which has its starting-point almost exclusively in adolescence and whose early stages are confined to that period. Its underlying disease-process is an enfeeblement of the heretofore normal intellect—a slow decline of mental power. It ends, generally after a few years, in a state of permanent mental degeneration, which varies in extent and degree, but which, as a rule, involves the mind in more or less complete and permanent disorganization. Its salient features are variable mental disturbances—often profound—which appear as protracted "attacks" in the course of the disease and consist in the main of irregularly occurring, episodical symptom-groups, chiefly stupor with or without katatonia or catalepsy, chorea insaniens, mania, melancholia, confusion, and pseudo-paranoia. A marked tendency to explosiveness and impulsive acts, contradictory phenomena, and remissions simulating recovery are characteristic of the disease. These various phenomena frequently mask for a time the latent and essential dementia.

The varieties and symptom-groups which are peculiar

to the disease are best studied by dividing it into the following classes:

CHARACTERISTIC FORMS.

Mild and Simple.	*Severe and Complicated.*
Hebephrenia.	Stupor (simple and katatonic).

ATYPICAL FORMS.

Pseudo-paranoia.	Confusion.
Mania (acute and choreic).	Melancholia.
Mixed States.	

Either of these states may be the predominating feature of an episodical syndrome of dementia præcox.

PREMONITORY SYMPTOMS OF DEMENTIA PRÆCOX.—As the early indications of the disease are practically the same whatever form it may afterward assume, and as their analysis is of importance as showing its true nature, they will be given in detail. The disease is of gradual onset as a rule, but the prodromal symptoms rarely extend over more than a year. The attack is reported to have come on suddenly in but twenty-two out of seventy-seven cases at the Taunton Hospital for the Insane and at "Bournewood." The primary manifestation is mild mental enfeeblement. Power of attention, the root of mental strength, is first affected. Kræpelin considers that at this stage the attention is intact, but that the patient makes no use of it, as he has no desire to occupy himself with anything. In all of our cases, however, in which intimate knowledge of the earliest manifestations was attainable, lapse in the *power* of attention has invariably preceded loss of desire to occupy the mind. An ambitious student complains: "I cannot any longer wield my mind, which has become my master instead of I being master of it," "I feel no exuberance as before," "Everything is a dead weight," "The feeling clings to me and I cannot *fight it off*." A bright lad in a preparatory school grows despondent at finding himself becoming "dull," "stupid," and "weak," and begs to be helped, as his utmost endeavors to go on have failed. The girl in this situation feels for the first time that "she must struggle to be like other girls." The patient also becomes more easily fatigued physically than before. With increasing mental failure the fruitless efforts are soon abandoned, the mind becomes more inactive, forgetfulness, despondency, and indolence replacing alertness, ambition, and energy. He "wants to be let alone," becomes listless, apathetic, and careless, gradually slipping into a dulled condition of mind. Another becomes mortified, sad, hyperconscientious, and self-reproachful. Avoidance of others follows and paves the way for suspicion of those about him, the starting-point it may be of future hallucinations, delusions, and overt acts. Suicidal thoughts may now appear. Patients of another temperament when no longer able to meet even the minor demands of life and physically tired are easily upset and very irritable. They become unexpectedly fault-finding and angry over trifling matters. Abulic states are common and are shown in marked indecision and constant demand for reassurance regarding the plainest matters of duty. The train of thought naturally becomes interrupted early and may even show signs of the approaching confusion and stereotyped movements of the next and active stage of the disease. Lapse in judgment is shown in unnatural prejudices, sudden and needless alarm at ordinary occurrences, foolish conduct, etc. The memory is unimpaired, although sometimes masked by the prevailing absorption and apathy. Self-control is early involved, diminishing until in the active stages it may be, in extreme cases, entirely lost. The conduct varies with the nature of the symptoms. Sudden and unexpected acts are common, such as exhausting walks with no object after a long period of idleness, destruction of minor belongings, etc. Sudden transitions of mood and the lack of depth of the patient's depression or anger, which are characteristic features of the disease throughout its entire course, are early manifestations, as are also inconsequential speech and aimless effort. The general appearance of the patient is that of apathy or mild depression, except at times of sudden animation. Lack of energy also is constant, except during spasmodic outbursts of misdirected activity. Although such patients owing to irregular ways of living sleep more in the daytime, insomnia is developed early. The appetite is capricious. Headache is as frequent, and, as Mairet thinks, a highly important symptom at this juncture. It is sometimes severe, persistent, and protracted pain, but more often in our experience a disagreeable vague sensation as if the head were "empty" or "filled with cotton wool." Nightmare appears to be somewhat more common than in the older insane. A generally weakened, relaxed, poorly nourished bodily condition is common and is shown in loss of weight, pallor, dilated pupils, vaso-motor disturbances, low temperature, and weak pulse. Menstrual irregularities are rather common. In not a few cases the group of premonitory symptoms bears a deceptive resemblance to neurasthenia proper, owing to the predominance, for a long period, of purely nervous and bodily debility. Careful inquiry will often reveal the history of a transient attack of "nervous prostration," a peculiar "seizure," or spasmodic attack some time before, in which mental phenomena were prominent. The apathetic condition of the preliminary stage often passes for depression. When the onset is more or less sudden these minuter changes are masked by the severer symptoms, and the mental fatigue and apathy are less prominent in the history as forerunners, but special inquiry for these indications usually brings them to light.

In spite of this array of symptoms these patients not infrequently show for a greater part of the time a degree of sensible conduct and natural enjoyment of things which tends to conceal their true condition.

MILD AND SIMPLE FORM.—*Hebephrenia* represents the mild and simple form of the disease and comprises those states which are characterized from the very outset to the end of the attack by simple dementia. This takes the form of mental enfeeblement in which alternate depression and excitement appear, but are never very marked. This variety may properly be said to bear the same relation to dementia præcox as a whole that the uniformly demented or uncomplicated form of dementia paralytica (general paresis) does to that disease. A study of hebephrenia proper is the best guide to an accurate knowledge of the elements of dementia præcox. It is a simple, gradual weakening of the intellect, and in its main features is fairly well defined, so much so that several authorities have regarded it as a disease in itself.

Active Stage.—In this group of cases there is rarely any decided or abrupt transition from the above-described initial symptoms to the active stage, which in a general way may be said to be reached when the patient's self-neglect, erratic conduct, impulses, suicidal tendencies, etc., have reached the point of unmistakable irresponsibility and call for medical interference and perhaps hospital care. Sometimes the advent of this stage is marked by a light and transient attack of excitement or by the appearance for the first time of active delusions and illusions. The semi-depressed condition now becomes more pronounced., The patient accuses himself of wrong-doing, believes that he is worthless, is bringing trouble on others, etc., and makes more or less determined attempts at suicide, wanders off, giving the family great anxiety, or refuses to leave his room at all. The feeling of sadness, however, unlike melancholia in older patients, is very superficial and readily changes to another mood for no apparent reason. A young man, for example, while in the midst of bemoaning his evil life suddenly stops, takes up his guitar and sings a comic song in a mechanical, impassive manner. A girl with placid and even smiling expression tells of her terror from the smell of burning bodies beneath her bed. A sudden access of gayety with loud laughter and foolish behavior will often interrupt the melancholy. So, too, anger, however frequent, is soon over—perhaps dispelled by a sudden change of mood. The greatest contrasts in the mental states are to be expected in this disorder. The psychomotor sphere is equally involved. The patient abandons himself to all kinds of impulses and aimless acts which often have the appearance of being done

from mischief or malice. In writing and speaking they are sometimes affected, grandiloquent, declamatory. They may write high-flown sentimental and disconnected doggerel, or draw absurd symbolic pictures. Great vanity or absurdly dictatorial manners are not uncommon. One is impressed with the shallowness and unreality of the sentiments of these patients. Their ideas in general are childish. They often realize that they are ill but they have a wrong idea of their condition. Memory, consciousness, orientation, and order of thought are usually well retained except on occasions of excitement, when there are lack of clearness and confusion. The understanding is greatly impaired, as is shown in unnatural opinions on ordinary matters, in actual delusions, in difficulty in grasping new ideas, and, as the disease progresses, even simple ones, in inability to follow plain explanations, etc. Emotionally they are more or less apathetic, listless, and dull for a good part of the time, a condition which may occasionally take on a semistuporous phase. Sometimes excitement is quite marked, but it is transient and actual violence in this state is rare. Extreme and very sudden impulses are common. Hallucinations are frequent at first and shifting delusions of a depressive kind prevail. In fact, the predominating feature for a time may be simply the reiteration of absurd delusions of culpability, etc., with perhaps little expression of concern. The more apathetic rarely take the initiative in, or apply themselves to, anything, but sit idly about, and, if work be given them, soon abandon it. They will turn the leaves of a book without reading it, etc. They show no spontaneity in conversation, and their answers are perfunctory. Their movements are often slow and mechanical. The expression, usually more or less vacant in such cases, may be broken by a weak smile or meaningless laughter. If these patients leave the hospital, they are apt to be unfit for duties of any kind. They shun others and take little or no interest in anything, but are able to live at home in the absence of harmful impulses or habits. Many of the poorer class become tramps or beggars.

Severe and Complicated Forms.—*Stupor.*—In the preceding variety the prevailing mental state was chiefly apathy or light hebetude. We have now to deal with stupor, a more extreme and acute state in the "dementing" process: a suspension, in varying degrees, of mental activity. Here the consciousness is more deeply involved and the symptoms are more pronounced, so much so as to include physical as well as mental disorder. Its protracted nature and accompanying phenomena render it characteristic, but the stupor of general paresis and of epilepsy is very similar to it in other respects. Stupor seldom comes on suddenly, although occasional cases are reported to have immediately followed extreme fright, profuse hemorrhages, etc. It may, however, be a comparatively early symptom. It is usually preceded by certain of the prodromal symptoms above described as common to all forms of dementia. Depression and general indifference may simply deepen into stupor. Hallucinations or illusions with fear, or intense transient excitement and violence may precede it. Hysterical manifestations may also appear before or with the excitement. The circulation is often poor, the appetite impaired, and sometimes the sensation is diminished. After a few days or weeks in such cases, in others after months, stupor sets in, growing gradually deeper, while the hallucinations slowly disappear. In cases of profound stupor, either complete relaxation or rigidity of the muscles may be present. The patient becomes motionless and so remains, except when interfered with by others, and in exactly the same attitude for days, weeks, or even months. He is often found standing rigid with the head flexed upon the chest, the eyes closed or staring vacantly without winking. Flies may crawl over his face unheeded. His evacuations are passed unnoticed wherever he may be. He refuses food, answers no questions, and often cannot be aroused by a pin-prick. That he feels and even hears, however, is sometimes evidenced by his turning his head to the questioner. The respirations are barely noticeable, the heart sounds clear but weak, and the pulse is irritable, small and soft. The extremities are cold and perhaps œdematous. The temperature is below normal, the skin dry and harsh, the body thin, and the face cadaverous. Menstruation is abolished. The stupor may be suddenly and unexpectedly interrupted at any time by a transient attack of excitement lasting a few minutes or an hour, after which the stupor returns. So, also, equally brief intervals of apparent rationality may occur and disappear during the profoundest stupor. Cases of intermittent mental stupor are reported by Whitwell and Noble, one in which lucid periods of twelve hours alternated every thirty hours with typical stupor, for a year and a half; another in which there was a fairly regular alternation of these states every day for at least five months. Every degree of stupor may be present in a case of dementia præcox, from the well-developed type just described to a milder apathetic state approximating that of hebephrenia.

One of the most characteristic symptoms is a peculiar state of muscular rigidity or spasm, generally called katatonia (*κατα*, denoting intensity; *τονος*, tension). The association of this striking motor condition with various alternating psychical symptoms—melancholia, mania, stupor, confusion, and finally dementia, one or more of which may be absent—led Kahlbaum, in 1874, to regard katatonia as a disease entity, naming it from this symptom which he believed to be pathognomonic. Until recently the soundness of this view, which has much to commend it, has been a much vexed question, but it is now practically rejected by the modern writers. Kraepelin classes it as a form of dementia præcox. Our own observation, which is in accord with Chaslin, Séglas, Tuke, and Goodell, inclines us to go even farther and, regarding it as a symptom, to subordinate it to the more comprehensive form, stupor, of which it is a direct outgrowth.* Stupor, it will be recalled, frequently runs its course without katatonic symptoms, while the katatonia of dementia præcox seldom originates independently of stupor in some form. It rarely accompanies excitement except when the latter is associated with stupor—a not uncommon combination.† Katatonia does not develop *pari passu* with stupor in a given case, but is most marked when the stupor has become profound, and is an indication of its intensity. In short, when the acute dementia becomes extreme, motor inhibition with muscular rigidity may follow. In well-developed katatonia all the muscles seem strained to the utmost, and this state of persistent tension and rigidity enables the patient to maintain even unnatural and difficult positions and postures for a great length of time, perhaps for months. Occasionally, for want of proper treatment, ankylosis results.

The katatonia is intensified by any attempt at interference with the attitude or position of the patient, who will often make stubborn and it may be insurmountable resistance. This well-known phenomenon has been accurately named negativism on account of the patient's determined opposition to natural direction and personal promptings. The efforts that are necessary to deal properly with these patients are extraordinary in consequence of their dogged resistance to all attempts to help them. It is sometimes possible to accomplish the end in view by appearing forcibly to prevent the patient from doing what we desire. Refusal of food is a prominent example of this tendency, and the same difficulty in forcibly feeding the patient is regularly encountered with each attempt. There is a like resistance to the functions of defecation and micturition. The saliva also is retained for a long time in the mouth, the same inhibitory motor condition preventing the patient from swallowing it.

Cataleptic conditions—by which is meant states of stupor associated with suggestibility and often a waxen flexibility of the limbs on passive motion, which is in strong contrast to the muscular rigidity of katatonia—are not uncommon. The mental attitude is equally opposed to that of katatonia, being, in many cases, manifested in increased susceptibility to external impressions.

* See also McPherson: "Mental Affections," 1899, pp. 234, 236.
† See Kraepelin: Am. Jour. Ins., lvii., No. 3, pp. 464, 467, 468.

The patient is sometimes as obedient and pliable as the katatonic patient is contrary and resistive. Sometimes the tetanic rigidity of katatonia and the cataleptic flexibility are associated, the katatonic spasm developing first,—a combination difficult to understand on physiological grounds (Kirchhoff). Certain cataleptic patients are very imitative. They spend much time in mimicking the motions of others and will continue the same movement automatically for hours.

The mental state in stupor may represent almost every degree of intellectual inactivity, and in the profoundest states thought seems practically suspended. To some extent the patient is influenced by powerful delusions, fears, or hallucinations, to remain motionless, etc., as is evidenced by questioning the patient on recovery, but more often the mind is found to have been more or less of a blank, as the patient has little or no remembrance of what his feelings or thoughts had been during the stupor and can give no reason for his behavior at that time.

THE ATYPICAL FORMS.—The other varieties of mental disturbance occurring in the course of dementia præcox are not so characteristic of the disease as are those just described, and, as they are not confined to any time of life, may in a sense be called the atypical forms of the disease. As we shall show in speaking of the diagnosis of dementia præcox and elsewhere, these forms are here symptomatic and only superficially like the same forms later in life where they are consistent mental states which have been regarded as psychoses. They are melancholia, mania, confusion, and pseudo-paranoia.

Melancholia.—The melancholia of dementia præcox very frequently ushers in the active symptoms of the disease, which may become either deeper melancholia, a maniacal episode, or a protracted stuporous condition. Simple apathetic states occurring in the prodromal stage and later are, we may be permitted to repeat, often mistaken for depression. When melancholia is the prevailing state it is apt to take the form of self-accusation, delusions of worthlessness and culpability, with illusions and hallucinations which may be very pronounced. The absurdity of the delusions is a marked feature in some cases; a patient believes, for example, that when taking food she is eating people or swallowing diamonds, that there are people concealed in her skirts, etc. Occasionally the delusions are powerful and lead to attempts at suicide, homicides, and escapes.

As has been shown in describing the hebephrenic form, the feelings are seldom deep and the disproportion between the intellectual disturbance and the emotional condition is often striking. The consistent, constant, and pronounced remorse, self-disgust and despair or continual terror, desperation and agitation which nothing can mitigate, of the mature melancholiac, is not often seen in the adolescent patient. The depression and delusions are often much in the background, and while they color and influence the attitude and behavior are apt to come into especial prominence only occasionally and as startling and frequent impulses or sudden determinations to follow peculiar lines of conduct—to refuse food, for example. These patients are often appreciative of their surroundings in the acutest stage of their depression and may be quite readily diverted. The underlying mental weakness at this time is shown in nonsensical ideas, a childish manner, apathetic states, and fatigue of mind following slight application or unexpected events, such as the visit of a relative, etc.

Mania.—It is usually after a transient period of apathy, depression, or peculiar conduct that the excitement of dementia præcox very suddenly breaks out, and in extreme cases is for a time intense and furious, continuing so, it may be, for a few days or even a week or two, to be succeeded by a dull apathetic state, and to return again with perhaps less intensity. This alternation continues irregularly throughout the greater part of the attack in a certain number of cases, the excitement becoming less and less prominent. As a rule the maniacal stage consists of a rapid series of impulsive acts of various kinds. The violence is often of a senseless nature; the delusional state is marked and hallucinations are common. The patient will often stop in the middle of his excitement to answer questions and express appreciation of his condition or surroundings. Stereotyped movements are common; the most violent opisthotonos was maintained at different times during excitement, for half an hour or more, by two of the writer's patients, in one of whom it alternated with extreme emprosthotonos. Isolated imperative acts in great variety, usually sudden, extreme and momentary violence or strange actions in endless repetition, attitudinizing, etc., often interrupt the quieter or replace the excited condition. The maniacal form of dementia præcox is not very common. Verbigeration, in which words or meaningless sentences are repeated in the same tone for hours or days together, is thought to be a common feature of the disease, but the writer has only occasionally seen this symptom in dementia præcox. Goodell, in a three years' study of these cases, had not met with this so-called characteristic symptom as described by Kahlbaum and Neisser, and French writers deny that it is characteristic of any affection whatever.

Mania is associated in rare cases with chorea major, making a striking disease—*chorea insaniens*—which we should class among the characteristic forms of dementia præcox were it not that the accompanying mania is the predominating condition, of which the chorea usually appears to be a motor complication. These patients often have previously manifested one or more of the physical ailments common to this period, viz., anæmia, scanty or irregular menstruation, palpitations, cephalalgia, etc., and are very frequently adolescent primiparæ. It has long been recognized that chorea in some form is almost invariably associated with mental impairment, varying from apathy, irritability, etc., to acute mania or stupor. It is equally true that chorea is in its most developed state in youth and that the associated mental symptoms are most marked then, the severe, dangerous, and fatal cases occurring at this time. It is also noticeable that the choreic and mental symptoms appear and subside at the same time, a fact which suggests the close alliance of the two disorders. As the acute forms of both do not appear together at any other time of life, choreic insanity, or maniacal chorea, plainly belongs exclusively to adolescent insanity. In the choreic form of dementia præcox heredity seems to play a somewhat more important part than in the other varieties. The onset is generally rather abrupt, the choreic and mental symptoms usually appearing simultaneously, but either may precede. Delusions or hallucinations now appear which may later dominate the scene. Insomnia and nightmare are common. Increased temperature is not infrequent in this stage. The chorea, whether general or localized, reaches its height early in the attack, which is usually not the case with the mental state. The choreic movements also are almost invariably increased during the mania. When at its height the patient writhes incessantly, plunges about the bed, tosses the arms, clenches the fists, contorts the face, etc. The knuckles and elbows become abraded unless protected from the wall or bedstead. The maniacal condition is the same as a rule as that just described as the ordinary maniacal form of dementia præcox. The duration of chorea insaniens is usually several months. It is often fatal, and is believed by some investigators to be due to sepsis or a toxin.

Confusion is a frequent condition and the logical expression of the mental process in dementia præcox, a disorder which presents so many and frequent contrasts in moods and even in its forms of disturbance. Moreover, exhaustion, which is the basis of confusional insanity, is also, as will be shown, a most common cause of dementia præcox, and we should therefore naturally look for similar clinical manifestations in both. In our opinion many an attack which passes for simple confusional hallucinatory insanity of the primary idiopathic type in adolescence is the starting-point of dementia præcox. In fact, Chaslin's classic description of confusional insanity embodies so many of the well-known symptoms of dementia præcox that the resemblance is striking. For example, he classes

together as important symptoms of confusional insanity intellectual enfeeblement, stupor, immobility, automatism, dementia, stereotyped movements, impulses, etc. According to Meynert the prevailing age in confusional insanity is between twenty and thirty. Although hallucinatory confusional insanity in its entirety is only occasionally present as a symptom-group of dementia præcox, the mental state of confusion is a prevalent and consistent feature of the disease.

Paranoid States.—Just as hebephrenic and stuporous conditions arise in the progress of this dementia, in the same manner that mild demented forms and stupor occur in dementia paralytica, so also pseudo-paranoia will appear in dementia præcox in the same way that persecutory ideas are for a period uppermost in certain cases of general paralysis. These paranoid states, which are quite common, are very different from true paranoia, as will be shown when we come to consider the diagnosis. They are so designated simply because the predominating ideas and attitude are those of persecution. These beliefs are usually not the outgrowth of a naturally suspicious tendency, but are preceded by certain of the usual prodromes of the disease above described as common to all forms, chiefly insomnia, headache, cerebral fatigue, loss of interest, etc. There is also much disquietude, suspicion, and irritability, and the active stage is apt to begin with excitement or pronounced melancholia followed by hallucinations and delusions, which, though absurd, inconsistent, and unsystematized, are persecutory in their nature. The delusions are often attended with ideas of grandeur and importance. A young man, now a dement, would dwell on long-past family misunderstandings as present grievances which demanded redress. Relatives "insulted" him and made derisive motions to him. He ordered people out of the house, grew excited, and talked loudly in discussion, was overbearing, and fell into rages in which he proclaimed his importance, forbade speaking of the President in his presence, etc., etc. These patients are very vain and self-conscious and demand special consideration. Their understanding is much affected, and they cannot long apply themselves to work or reading. Impulsive acts are common. In a variable length of time they show the underlying state in increasing apathy, and in a few years the disease ends in a confused dementia. Remissions occasionally occur, as with the other forms of dementia præcox, but they are usually short. Paranoid conditions may appear for the first time late in the second attack or after its acutest stage has passed. Hallucinations of hearing and persecutory ideas, developing late in this way, may terminate in what is loosely termed secondary paranoia, a common condition.

Mixed States.—It has been already made apparent that none of the above symptom groups are always consistent sets of manifestations except as they represent modes of expression of one underlying condition, dementia. A single syndrome is merely a predominating feature, which often may hold the stage only for a time, to be interrupted or entirely replaced by an opposite condition. Thus it happens that stupor will sometimes dominate a mild hebephrenic state for the time, and confusion, katatonia, and excitement be intermingled in the same attack, etc.

Miscellaneous Conditions.—Like dementia paralytica, the mental manifestations of dementia præcox are Protean. Besides the principal conditions just described, hysteria is a common element and epileptiform attacks and delirious states are occasional complicating features of the disease. Aboulia and hypochondria are sometimes present when bad heredity is a prominent etiological factor.

The Disease-Process.—It is only by keeping in mind that gradual intellectual enfeeblement is the fundamental condition of dementia præcox from first to last, growing more and more marked with each successive "attack," and that even in the remissions it is in typical cases more or less apparent, that the true nature of the disease can be understood. Any of the groups just described may predominate in one attack and in the next be absent, greatly modified, or united with the symptoms of another group, but the mental enfeeblement is the one constant feature which is at once the source and common bond of union of all the manifestations. Some of these syndromes are moreover striking and, relatively to mental states in mature life, unusual. This is because the underlying juvenile dementia has imprinted on them a peculiar stamp, making them odd, shifting, and contradictory. The intensity and depth of these manifestations, as well as their irregular character, so far conceal the essential dementia in some cases that it is apt to be lost sight of and these accessory symptoms are given an undue importance. This and the fact that remissions have been taken for recoveries have led observers to mistake them for disease entities which have been given from time to time a variety of names, such as stuporous insanity, acute primary dementia, katatonia, hebephrenia, melancholia attonita, etc. Much confusion has arisen in consequence, and the real nature of the disease has been greatly obscured. They are in reality but episodes in the course of a progressive dementia, and have their counterparts, as Kraepelin indicates, in the excited, depressed, stuporous, katatonic, confused, and other states that mark the course of dementia paralytica or general paresis.

It is instructive further to develop this analogy, if we may so term it, between dementia paralytica and dementia præcox, as there are features in both diseases which show a certain clinical relationship between the two, at least so far as concerns their *purely psychical* symptoms and the process of development of the mental degeneration. Kahlbaum in his work on katatonia finds some striking points of resemblance clinically and even reports autopsies on cases of that disorder in which certain pathological changes were the same as those found in cases of general paralysis (see *Brain*, vol. xii., July to January). Kraepelin makes several allusions to clinical points of resemblance in his chapter on dementia præcox.

A Comparison of the Modes of Mental Degeneration in Dementia Paralytica and Dementia Præcox.

Dementia Paralytica.	Dementia Præcox.
Nature and Course.	
A primary *organic* dementia, an essential, general, progressive, and chronic mental enfeeblement.	A primary "*functional*" dementia, an essential, general, progressive, and chronic mental enfeeblement.
Etiology.	
An acquired disease.	Either inherited or acquired.
Mental Prodromes.	
Prolonged :— A period of pseudo-neurasthenia. Impaired attention. Mental fatigue. Indifference. Irregularity of habits. Early impairment of moral sense. Memory impaired.	Usually prolonged :— A period of pseudo-neurasthenia. Impaired attention. Mental fatigue. Indifference—common. Irregular ways of living. No impairment of moral sense until later stage. Memory intact.
General Mental Manifestations.	
A union of mental and physical symptoms.	Union of mental and physical symptoms in many cases.
Special Mental Manifestations.	
Protean, but chiefly— Dementia (uncomplicated). Mania. Melancholia. Stupor. Confusion. Paranoid states.	Protean, but chiefly— Dementia ("hebephrenia"). Mania. Melancholia. Stupor. Confusion. Paranoid states.
Special Physical Symptoms.	
Essential, constant and profound— Speech defects. Localized tremor. Muscular inco-ordination. Pupillary troubles. Troubles of sensation. Automatic movements. Convulsions. Spinal lesions, etc.	Common, often profound, frequently absent— Katatonic rigidity or spasm. Stereotyped movements. Chorea. Cataleptic "trance" states. Peculiarities of gait. Analgesia. Vaso-motor disturbances.
Remissions.	
A prominent feature—almost invariably incomplete, usually transient, rarely protracted.	A prominent feature—generally incomplete and short — sometimes quite complete and protracted.

DEMENTIA PARALYTICA.	DEMENTIA PRÆCOX.
Termination.	
Invariably fatal—gradual destruction of mind and vitality.	Rarely fatal—destruction or permanent impairment of mind only.

The above comparison shows plainly that in spite of the wide difference in their pathological bases the mechanism of the process of mental deterioration is practically the same in both diseases, the depth of the pathological involvement of the cortex alone explaining the difference in the ultimate results. It also makes it evident, to our mind, that dementia præcox is a transition disease between the "functional" degenerative psychoses, paranoia, manic-depressive insanity, etc., on the one hand, and the deeper-seated (because structural) form, dementia paralytica, on the other.

ETIOLOGY.—*Age.*—The profoundest influence in originating dementia præcox is the normal condition of the organism at the time of life in which the disease prevails—the period of puberty and adolescence,—of growth, development, immaturity, whose limits lie in the large majority between the ages of fourteen and twenty-five. In fact, the unmistakable cases of dementia præcox that occur later than the thirtieth year are rare. Almost all modern writers on psychiatry, even those who lay especial stress on the influence of faulty heredity, are fully alive to the great importance of this critical time of life in promoting mental disease. Kraepelin in particular, who has little to say regarding heredity as a cause of dementia præcox, thinks that in all probability we shall have to seek for the real causes of its origin in the physical and mental variations of the period of development.

There is no dividing line between puberty and adolescence so far as concerns the general formative influences which underlie physiological and pathological conditions in youth. In this article, therefore, the term adolescence alone will be used—and in its legitimate sense—to designate the entire period of development from the advent of puberty to maturity.

To appreciate the possibilities of this epoch we have only to call to mind the unusually rapid growth of the organism in every tissue, the new and powerful activity of all the functions, especially those of nutrition, in the progress toward complete development, and the stamina and often the care that are essential for properly meeting the demands of this revolutionary period. The disturbance of the heretofore tranquil nervous system by the advent of the reproductive functions is a vital change, and the proper adjustment of this part of the system to the working whole is of far-reaching importance, as the genital activities have a profound effect on the entire organism and the developing personality.

The normal mental condition is equally unsettled during adolescence, and now, if ever, should we especially fear its pathological disturbance when impressionability, instability of purpose, variation of mood, excitability, impulsiveness, ambition, independence, and intolerance are most likely to be in full play, when the affections, emotions, and newly awakened sexual feelings and passion are most keen, when reflection and judgment are immature, and, above all, when the self-control which should regulate all is itself in an imperfect stage and in danger of being unequal to its function. Nothing is more significant of the causative influence of this period than the resemblance of the clinical picture to these ordinary psychical attributes of development which are all found morbidly exaggerated in the different clinical forms of the malady.

Heredity.—That inherited predisposition to insanity is the preponderating influence in the causation of dementia præcox or its synonymous conditions is not well established, although most authors, among whom are Krafft-Ebing, Finck, Clouston, Morel, Jules Falret, Magnan, Jaffray, and Saury, hold that the disease is essentially hereditary. On the other hand, Kahlbaum, Hecker, Scholz, Marro, Daraszkiewicz, Régis, Christian, and apparently Kraepelin, consider this influence to be at most but secondary in importance. Christian, in a most searching investigation, could find but 43 in 100 cases of dementia præcox who had had insane relatives. The writer's statistics on this point comprise 23 cases of the disease in which the means of obtaining reliable family histories were exceptionally good. In 21 known cases 11 had no personal or family history of mental or nervous diseases. Dr. W. H. Miller, pathologist of the Taunton Hospital for the Insane, has kindly investigated most carefully for the writer 56 cases of dementia præcox on this point, with the result that of 39 whose family history given in detail was apparently reliable, 25 were free from such hereditary taint. Thus, in a total of 60 cases coming under the writer's notice, 36 could fairly be said to show no hereditary predisposition to insanity or nervous disease. In this connection we would refer the reader to the suggestive table in the article on General Pathology (page 36), which gives the disease heredity of normal persons. We would not belittle the influence of hereditary taint in these patients, but regard the question as one of degree, and in the scale of hereditary disease would place dementia præcox between manic-depressive insanity in which insane heredity figures very largely, and dementia paralytica which is an acquired disease without appreciable antecedent mental defect. We are also inclined to the belief that inherited lack of stamina and general vigor is at the root of the trouble, a condition that is not necessarily transmitted by insane relatives.

The evidence is even stronger that it cannot be properly classed among the insanities of degeneration. The absence of the physical and mental stigmata of degeneration in the writer's cases was general, and statistics could be multiplied would space allow to show that, as Daraszkiewicz observes, neither the frequency nor the gravity of these signs is sufficiently marked to make it possible for them to imprint a special stamp on the disease.

Another striking fact in this connection is the frequency with which the disease attacks adolescents of marked intelligence and promise—ten of the writer's twenty-two patients were so endowed, and but one was below the average young person in intelligence. A large number of patients who are subject to katatonia are schoolmasters, the sons of schoolmasters, and theologians (Kahlbaum). Christian finds the following statistics of Aschaffenburg in absolute accord with his own: 27 per cent. men and 21 per cent. women had average intelligence; 55 per cent. men and 66 per cent. women had good and even remarkable intelligence; 18 per cent. men and 13 per cent. women were below the average in intelligence, but neither idiots nor imbeciles.

Facts such as these are very instructive and tend to show conclusively that dementia præcox is very often an acquired disease so far as any psychosis can be properly so designated.

Acquired Predisposition.—Diseases of early childhood of all kinds that tend to make the system delicate are fertile soil for dementia præcox. Such are the various eruptive diseases, especially scarlet fever and measles with their sequelæ; typhoid also, acute rheumatism, diphtheria, digestive troubles, anæmia, and cranial injuries. Convulsions in infancy, chorea, and headaches if prominent in the child, betoken delicate nervous health, calling for special precautions in adolescence.

Badly directed education, moral and mental, may give a wrong turn to the child's tendencies, and thus leave him without defence against the exciting causes of mental disease when adolescence is reached.

Occasional and Exciting Causes.—The determining causes are various, but for the most part are of the nature of exhausting influences. These are the most conspicuous and powerful of the exciting causes of the disease and give great weight to the contention of Binswanger and Christian that dementia præcox belongs among the exhaustion psychoses.

Rapidly growing youths or girls—particularly of the lower classes, apprentices, clerks, train hands, stable boys, mill operatives, domestics—often succumb to the exhausting effects of hard physical labor combined with long hours, little sleep, insufficient food, and, in conse-

quence, disorder of nutrition. Insomnia and lassitude arise and mental breakdown follows, often without the aid of any appreciable predisposition to insanity. Youthful volunteers, not inured to military discipline and the hardships and dangers of active service, also recruit the ranks of the youthful insane. Intellectual overwork, of itself rarely productive of mental disorder, causes many a delicate girl or lad to succumb to insanity when poor circumstances increase the struggle for education. Rapid and excessive growth in stature is very frequent in hebephrenics and precedes by a little the development of the psychosis. In these instances there is not sufficient alimentation provided to meet the demands of the growth of the organism *plus* excessive mental and bodily energy. Habitual masturbation and venereal excesses contribute to the exhaustion, but it should be borne in mind that masturbation is oftener a result than a cause of mental trouble, and its importance as a factor is much exaggerated by people in general and especially by the melancholiac with delusions of culpability. Typhoid and other debilitating diseases not unfrequently leave the patient in a permanently weakened mental condition, culminating in dementia præcox.

The puerperal state, with its many disturbing influences in various directions, is a prominent determining cause of the disease. Aschaffenburg finds 56 cases of dementia præcox in 118 cases of "puerperal insanity."

Other determining but less frequent causes are alcoholic excess, fright or other shock, chagrin, disappointment in love, long engagements with consequent strain on the emotions, and religious revivals. Finally, it may be impossible to find any adequate cause for the mental breakdown, a small proportion of cases occurring in the physically strong and apparently unemotional.

Sex.—No reliable data have thus far been recorded which indicate in which sex the disease is more common. This is probably owing to the differences among observers as to what cases should be included under this head. There is, therefore, no accurate knowledge as to whether or not the supposedly debilitating and other effects of menstruation and its irregularities come into play as causes. Not a few authors, Christian among them, even find the disease more prevalent in youths. The writer's statistics show 41 girls in a total of 83 adolescents so affected.

STATISTICS.—The number of patients admitted to Taunton Hospital for the Insane in fifteen months, 563; dementia præcox cases admitted to Taunton Hospital for the Insane in same fifteen months, 126; dementia præcox cases admitted to Taunton Hospital for the Insane in fifteen months, twenty-five years of age and under, 76; ratio of dementia præcox cases to admissions, 23 per cent.

The writer received successively at "Bournewood" 147 private patients suffering from all forms of insanity, in which out of 23 of dementia præcox 22 were under 25 years of age. More cases of this disease who are of more advanced age are reported from public institutions for want of accurate histories regarding the time of onset and the number of previous attacks. Unfortunately it is also customary at present to swell the number of cases by including those beginning in mature life, that are known as "paranoia degenerativa" (MacPherson) or "dementing paranoia," in the category of dementia præcox, which is quite a different disease from paranoia in any form.

DIAGNOSIS.—It is of the highest importance as regards prognosis and prophylaxis to recognize dementia præcox in its incipient stage. This is no easy matter, so nearly do its early symptoms of mental and bodily weakness resemble in many cases the nervous exhaustion of true neurasthenia, which, however, is ordinarily a post-developmental disease rarely terminating in insanity. In early dementia præcox we miss the characteristic symptom-groups of neurasthenia: cerebral, digestive, genital, etc. The general hyperæsthesia, excitability, pains in limbs, back, etc., are rarely present. So also the phobias. The fatigue of mind and body on moderate exertion are common features of the two disorders, but in the psychosis the signs of mental inadequacy for work or pleasure, owing to loss of the power of sustained attention, will be found to preponderate over those of purely nervous and muscular weakness. Inquiry should always be made regarding previous transient attacks of the kind mentioned in describing the prodromal stage.

The chief difficulty in the diagnosis of dementia præcox in its active stage is to distinguish early attacks, in which excitement or depression may predominate, from manic-depressive insanity, a highly hereditary form of mental disease, which in a fair proportion of cases also makes its first appearance in adolescence. As one is a disease of active mental deterioration and the other a periodical psychosis in which the mind is sound until the last, except during the attacks which characterize it, the importance of a correct diagnosis is obvious. (See *Insanity: General Prognosis.*)

In certain cases it is extremely difficult to differentiate between the two until a second attack has occurred or until the disease, if uninterrupted, has become so prolonged that evident signs of deterioration appear. The general features of difference are, that dementia precox has a gradual onset, while the attacks of manic-depressive insanity appear suddenly as a rule, and there is an absence of ascertainable cause. The former has irregular intervals between the attacks, in which the mind usually shows increasing impairment, but in the latter rational intervals always prevail. In the one the attacks vary greatly as to intensity, frequency, and regularity; in the other they are uniformly either mania or melancholia of about the same intensity and duration, and recur with considerable regularity especially in the circular form. In dementia præcox the degree of mental deterioration is out of proportion to the degree of severity of the depression or excitement. Regarding the special mental processes of the two: when depression occurs in dementia præcox it is not so likely to be attended with psychomotor retardation; the ideas are absurd and, as has been said, there is little depth to the feeling of sadness or shame. Such patients are often easily diverted, and sudden interruptions of the prevailing mood by a lucid moment or an opposite mental state are not uncommon. The depression of manic-depressive insanity, on the contrary, is uniform, consistent, and constant, and psychomotor retardation is common. The mania of dementia præcox also shows more confusion, the movements are aimless, sudden, impulsive, occasional, and possibly stereotyped with, it may be, intervals of quiet. The mania appears as a succession of outbursts of intense excitement that are soon over, while that of manic-depressive insanity expresses itself in constant restlessness and multiform purposive movements. In the former the patient is not exhilarated as in manic-depressive insanity, but is indifferent and silly, and talks nonsensically or bursts into tears in the midst of his excitement. The admixture in one attack of any degree of stupor, true negativism, stereopy, katatonic or cataleptic conditions, marked confusion or choreic movements, stamps the case as one of dementia præcox. The diagnostic relations of these two diseases is further elaborated in section XIX. (*Manic-depressive Insanity*).

Attacks of genuine confusional insanity of the primary idiopathic variety occur most frequently in youth and should be regarded with suspicion, as they are often in reality nothing less than the first active expression of dementia præcox. The same disorder occurring in maturer patients is as a rule secondary and symptomatic, and often does not result in dementia owing to the greater resistive power to disease of the fully developed organism.

The stupor of dementia præcox, when unattended by katatonic or cataleptic conditions or by marked negativism, resembles the melancholic stupor common to older patients, which may also be present during adolescence as the initial attack of periodical or manic-depressive insanity. It differs from it chiefly in its relatively less gradual onset—in the absence of the antecedent and protracted period of melancholia with delusions which are the starting-point of melancholic stupor and which so strongly influence the patient as to lead to mental preoccupation, which finally deepens into stupor. The

stupor of dementia præcox, on the other hand, is more or less complete, often seeming to extinguish all mental activity, and is not only not consequent on depressive delusions, but sometimes immediately follows a stage of excitement. Moreover, the dementia-præcox patient retains as a rule only a hazy memory of his thoughts or condition while in the stupor, but the true melancholiac has usually a full recollection of a dominating delusion at that time.

The excitement and the stupor of dementia præcox have, however, their closest counterparts in the mania and stupor of dementia paralytica, a fact which suggests the deep-seated nature of the malady, but the nature of the prodromes and the absence, from dementia præcox, of memory defect, pupillary irregularities, increased reflex excitability, tongue tremor, and other motor complications, will usually make clear the diagnosis.

It is sometimes difficult, as Christian points out, to distinguish certain advanced cases of dementia præcox from imbeciles or idiots. The appearance and mental status of each are often so much alike that, in the absence of information as to whether the arrest of mental development occurred in infancy or in adolescence, dements of this class often pass for imbeciles. All that can be said is that the imbecile is more likely to show stigmata or malformations than the dement, and that the latter sometimes affords glimpses of a former intelligence which never appear in the imbecile. Fortunately such an error is immaterial, as it cannot affect the care or treatment of the patient.

The diagnosis of paranoid conditions is sometimes difficult, but it is rare for true paranoia, a post-developmental disease, to culminate before the thirtieth year. The essence of paranoia is also absent in these states, viz.: a gradually evolved and logically elaborated set of delusions which exclusively and unchangeably dominate the entire psychic life. In place of this we have a rather sudden appearance of new conditions, and a variable and unsystematized delusional state, whose only likeness to paranoia is the persecutory nature of the morbid ideas. There is also in these hybrid states an absence of physical and mental stigmata of degeneration. True paranoia, moreover, does not end in dementia. It is more difficult to distinguish the paranoid form of dementia præcox from a form of paranoia occurring in maturity which consists of a marked persecutory delusional derangement of rapid course ending in dementia. The reported cases and those we have observed do not show the signs of dementia at the onset of the disease, and lack the variability, superficiality, inconsistency, and remissions, which mark dementia præcox. Unfortunately a few competent observers have mistaken these "dementing" paranoias of mature life for dementia præcox, thus encouraging the belief that this disease whose essence is adolescence may frequently occur at a more advanced age, and also obscuring its true nature.

Prognosis and Progress.—It is necessary to discriminate between the immediate and the ultimate prognosis of dementia præcox, for the two are widely different. Most first attacks, especially if pronounced, result in what are considered by people in general and appear in hospital statistics as recoveries. They are, as has been explained, remissions, which vary greatly in completeness and duration. In a certain proportion—Kraepelin estimates it at thirteen per cent.—all symptoms of disease so completely disappear that the recovered patient can again fill his accustomed station in life, practically, as well as before. These individuals, however, never appear entirely the same in the opinion of near relatives, in some detail of judgment, disposition, conduct, or habits. Their endurance, also, is apt to be less. Even these cases may relapse after many years and sink into permanent dementia, and one can never feel sure that a permanent recovery—which is a rare event in dementia præcox—has taken place. The other extreme is the transient remission, in which the patients are happy, easily pleased and irritated, excitable, more childish than before the illness, and very soon fatigued in mind and body. They experience a relapse very soon after leaving the hospital, from which time the deterioration is rapid. Intermediate cases live comfortably perhaps for two, three, or more years, but on a much lower level of mental and bodily power and mental capacity than before the attack. A few are able to earn a moderate livelihood, and find a certain satisfaction in life, but all are regarded as failures by their friends, have lost their spontaneity and most of their interest, and, being unable to play their part in life, are more or less solitary, decline advances, and come to be regarded as unsociable or stupid. They are also very often peculiar in conduct, inconsiderate, irritable, perhaps boisterous, and ignorant of their real condition. Such patients are readily imposed on, and are sometimes as pliable as imbeciles. Girls in this stage of the disease are often and easily seduced and give birth to illegitimate children. It is usually safe to predict, in any patient originally of good mind, who has had good care, "recovery" or decided improvement in the course of a year from the beginning of the active symptoms of the first attack, but it is most difficult to foretell with certainty the character or length of the remission in any case. Severe symptoms, if of the acute order, are no bar to temporary "recovery," and stupor, however profound, especially if of comparatively sudden onset and not markedly katatonic, betokens a good remission, which is, we believe, more likely to be an extended one than after any other form, although the cases in which confusion, mania, and melancholia predominate are also frequently followed by long intervals of comparative mental health.

The cases that are classed in this article as purely hebephrenic are milder, and less decided in their manifestations and more likely to decline gradually into permanent dementia, not necessarily deep, without remission of any sort or with an occasional brief interval of lucidity. Profound stupor, although less rarely, may without change, except for flashes of intelligence, deepen into extreme and helpless dementia with fixed postures. Of the cases which have come under the writer's notice, those in which the acute condition was prolonged beyond a year and a half without remission have gone steadily on to dementia. Increasing mental inactivity, fixed manners, and stereotypy appear to betoken chronicity.

There is no doubt of the ultimate prognosis in the large majority of the victims of dementia præcox, however encouraging may seem the outlook on the patient's recovery from the original attack. Another attack sooner or later occurs, others follow at intervals, and the mind rapidly deteriorates until a condition of dementia results, which is usually so extreme as to require constant hospital care or its equivalent. This terminal dementia is often marked by exacerbations of excitement, depressions, and anergic states which are the rudiments of the original acute manifestations which are characteristic of the disease. These patients form a large proportion of the chronic dements in institutions. All, however, reach a stationary condition through the arrest of the cortical degeneration, and remain at different levels of mental reduction. A small proportion stop short of extreme dementia, and live in considerable comfort, satisfaction, even enjoyment, the life of imbeciles of the higher grades.

The progress of the form of degeneration peculiar to dementia præcox may be (1st) progressive and subacute without critical episodes; (2d) slow at first, then rapid after a single acute episode; (3d) very slow and marked by numerous acute episodes (Finzi and Vedrani).

Pathological Anatomy.—Kahlbaum's admission that the pathological anatomy of "katatonia" had yet to be made is, unfortunately, equally true to-day of its parent disease, dementia præcox. What data we possess in the way of discovered lesions are very few in number and far from uniform. Many writers make no allusion to the pathology whatever. All that it is safe to say is that the essential mental weakness can be explained only by changes in the cortex. Altzheimer, in fact, describes marked alterations in the cortex, especially in the deep layers, in a few cases of collapse delirium which had presented the clinical features of katatonia. Auto-intoxication may account for some of these cases which are due to febrile and other forms of exhaustion and appear as

acute confusional conditions. Most of the pathological findings pertain to the profoundest mental state—stupor. Whitwell has attempted to explain its pathological and clinical signs by the congenitally diminished calibre of the blood-vessels. Kiernan finds a great analogy between the state of the brain observed in this condition and that found in cases of typhoid fever, but the essential and characteristic pathology of the disease is, according to him, a primary disturbance in the vaso-motor centres producing sanguineous stasis, and this, he maintains, is the point of departure of the whole morbid process.

Etoc-Demazy adduces evidences of general cerebral œdema from the autopsies of patients dying in stupor. (See also *IV. Insanity: General Pathology.*)

TREATMENT.—Of all the means for benefiting these patients preventive treatment is the most likely to be efficacious and the least apt to be employed. It is, nevertheless, possible for physicians to sow a seed of precaution by disseminating the truth regarding the dangers of adolescence that lie in the path of those who inherit or have acquired a predisposition to insanity, or are constantly exposed to exhausting influences. Intellectual overwork, the bugbear of most parents, is in itself a rare cause of mental breakdown, and in the writer's experience has never appeared except as a minor, contributing factor. It is the disadvantages under which study is being pursued—viz., late hours, outside work, insufficient food, anxiety, excess, unhealthy or distracting home influences—that have been chiefly responsible for the disaster. Clouston's "General Principles of Prevention" are practical and to the point. "Build up the bone and fat and muscle, especially the fat, by means known to us, during the period of growth and development. Make fresh air the breath of life to the young. Develop lower centres rather than higher when there is bad heredity. Don't give too much flesh and nitrogenous food during growth and adolescence. . . . Avoid alcohol and nervous stimulants absolutely if possible. Do not cultivate, rather restrain the imaginative and artistic faculties and sensitiveness and the idealisms generally in cases where such tend to appear too early and too keenly. They will be rooted on a better brain and body basis if they come later. Cultivate and insist on orderliness and method in all things. The weakly neurotics are always disorderly, unbusinesslike, and unsystematic. Fatness, self-control, orderliness are the three most important qualities for them to aim at."

There is also, we firmly believe, ground for hope of recovery at the very outset of the disease, and it is here that the immense importance of a knowledge of the earliest signs of cerebral fatigue become evident. The advantages to come of early recognition of dementia paralytica (a structural disease considered to be invariably fatal) are often and not without reason insisted upon. Is it not much more likely that good may come from the recognition of the prodromes in dementia præcox, a functional disease of at least long remissions and non-constitutional etiology in many cases? It is for this reason that we have dwelt so particularly on the minor mental manifestations of the disease in its incipient stage. We look with confidence to the time when cases recognized early by the alienist, while yet the patient is comparatively comfortable, may be saved from an attack by well-directed medical oversight and regulation of his habits and surroundings, insisting chiefly on rest of mind and body, abundant food, and life in the open air away from home. What might be called simple hebephrenic states that, under proper guidance, never culminate in insanity, occasionally reach the alienist and strengthen our belief in greater curability of the disease, at least among the well-to-do. When the disease has more fully developed it is well not to temporize. The danger of the patient's obedience to a sudden impulse to fatal or other overt acts, or an outbreak of excitement, is great as soon as the actually depressed or excited state appears, and proper precautions should be taken at once. The hospital is the only safe place short of single private care with special nurses and a physician in constant attendance, for such patients when once a suicidal or homicidal tendency has developed. Throughout the attack the main reliance is the patient's absence from home and relatives, experienced medical oversight and nursing, freedom from all disturbing influences, especially meddlesome attempts to entertain, quiet surroundings, regular exercise out-of-doors in almost all weathers, baths, and above all a good supply of nutritious food. Nothing is worse for so-called mild cases than to send them to travel. They are quite sure soon to return after unpleasant experiences, exhausted in body and mind, and in a far worse condition than before. Brain-rest, not diversion, is the supreme indication. Intervals between the attacks may often be prolonged by the physician if he is kept informed of the patient's condition. These young patients often emerge quickly from an attack, but while mentally clear are far from strong for some time. They require, in this condition, to be kept a longer time under immediate medical direction than the relatives are usually willing to allow, and thus are exposed to the danger of a speedy relapse. *Henry R. Stedman.*

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XVI. INSANITY, SENILE.—Under this general term are rather indefinitely grouped all those psychoses which develop in persons past the meridian of life and which are dependent upon those subtle changes in structure and function that mark the progress of declining years. Naturally enough we should not include in this group those cases of continuous or intermittent psychoses which begin in previous life and last to old age; nor yet, again, those instances of mental alienation in the aged which are due to intoxications, infections, or gross cerebral lesions described elsewhere in this group of articles; although, certainly, all these forms of mental disease might take on "senile" characters from coming within the sphere of influence of the characteristic senile changes. Our province rather is to depict the mental peculiarities coincident with these subtle physical changes; for we cannot doubt but that the primary variations, apparently only of function, are really dependent upon structural changes so fine as to elude the scrutiny of the microscope, but similar in kind to those which, later on in the disease, are more plainly discerned. And herein do we find our justification for including under this one head many cases which at first sight might appear essentially different. It may be that in the future, with closer pathological knowledge of these physical changes, defi-

nite subgroups or essentially different forms of brain degeneration may be separated from this somewhat promiscuous class; but for the present they are best considered together from a clinical standpoint. The whole course of the disease is chronic, with a marked tendency to a steadily progressive dementia.

It is well known that some people show the effects of their burden of years much earlier than others. From various causes, which will be considered later, these effects in certain individuals are most marked upon the nervous system, and include a pathological involution of the mental faculties. Thus the whole series of psychoses under discussion may be considered under the still wider term of involution psychoses. As this involution, however, sometimes commences quite early in adult life and affects too large and varied a class for separate discussion it has seemed best to restrict the bounds of the present chapter to include only those cases which commence after the forty-seventh year of life. The reader is referred to the chapter under Melancholia for a further consideration of this topic, as a large number of cases of typical melancholia really belong to this epoch in life and are but evidences of mental involution.

Senile insanity commences insidiously, and the early years of many cases present a marked clinical contrast to their later ones. This has led to an arbitrary but convenient subdivision of the subject into the *presenile* forms and the *senile* forms proper. Presenile insanity includes those cases which break down comparatively early, between the forty-seventh and the sixtieth years of life, while senile insanity proper is seen in those still older.

A. Presenile Insanity.—Presenile insanity is seen in a rather limited group of cases, which exhibit premature failure of their mental powers by an evident weakening of the judgment, undue emotionalism, and varied persecutory delusions. The onset is gradual; the clinical course, subacute or chronic; the usual outcome, a mild dementia.

There is usually a considerable period of vague premonitory symptoms. Imperceptibly a change takes place in the *disposition* and *habits* of the patients. They become more quiet, are unsociable, discontented, uneasy, and restless, sad without cause, irritable, and suspicious; have unreasonable outbursts of anger or tears, are disinclined to exertion. Their *memory* for passing events grows less acute. *Consciousness* is intact, and they are able to *orient* themselves perfectly. The *will* is seemingly unimpaired, but really they are less able to control their emotions and desires than heretofore. *Judgment* early shows considerable damage. They do not yet have hallucinations or delusions, although these are foreshadowed in their unreasonable whims and suspicions. There is usually some disturbance of digestion and general nutrition, and their power of endurance rapidly fails. The patients are really not yet insane, but are showing the first signs of mental inco-ordination: evidences of physiological involution of the faculties coming on at a prematurely early period, and with perhaps pathological rapidity; indications, in fact, of an essentially pathological process at work. They become extremely selfish and self-centred, introspective, and soon are definitely hypochondriacal. This attitude, with their general suspicions, forms the basis for their first delusions. They appear oversensitive to cold and complain of various disturbing conditions, "fleeting rheumatic pains," cough, hiccough, belchings, disagreeable feelings in the head and back, dizzy spells, distressing dreams, peculiar sensations in the eyes, and ringing in the ears. These are so numerous and absorb so much of their attention, are so changeable and easily allayed, as to suggest an hysterical condition. But more uncommon and unreasonable complaints point to the essentially delusional fabric of the whole group of symptoms. They believe that something has happened and has taken away all their strength, that their brain has been lost or been drawn out through the spinal cord, that they have no stomach, that nothing ever passes the bowels, that their heart does not beat, and that they live without any circulation of the blood. Things do not appear the same to them, and they immediately suspect foul play. A forgotten piece of wearing apparel has been stolen. If it is found, they cannot believe it is the right one, but a clever substitute, and still accuse the supposed thief. At other times poison is put in the food, they taste alum on their meat, saltpetre on the toast. They are convinced that some one is planning a deep game against them, and do foolish things to overthrow their schemes. One patient had a large hearth stone removed to uncover the dynamite secreted beneath. They do not usually name their enemies, but seem content with vague suspicions. When they do, however, they generally accuse some near friend or relative of enmity or unfaithfulness. In fact, the idea of conjugal infidelity is rather common with them; although it does not seem to produce the degree of excitement that would naturally be expected. One's wife is common property to a number of his neighbors, makes secret "dates" with the hired man. The husband makes business trips that he may get away with his paramour, he is too intimate with the servant girl, and, in fact, is thought to be flirting with all the women of her acquaintance.

Hallucinations sometimes appear with the delusions, but more often not until later. The patient feels by a peculiar tingling in her hand that her husband has met with an accident, she can feel the corrosive action of supposed poison in the stomach; another patient says that the meat is disgustingly "embalmed," he can taste the chemical preservative; he sees dark phantom shapes at night, sometimes robbers come into the room and reach over the bed, or he sees them down-stairs getting away with their plunder; he hears his wife talking with another man in an adjoining bed, overhears plots in the next room, his daughter's screams as she is being carried off.

It is to be especially noted that these delusions and hallucinations are very transitory and ever changing. In this early stage outrageous conceptions may seem to call forth no particular demonstration nor incite to vigorous measures to pursue the culprit. This is associated, it may be, with such calm and otherwise reasonable conversation as might lead one to suspect the patients did not believe what they were saying themselves. Often, again, a few soothing words may quiet all their agitation and they will seemingly be convinced that what they said was untrue; but a moment afterward they are relating some similar terrible thing. They have been persuaded to agree with their companion, but are not truly convinced, as they never fully realize the full gravity of their accusations. And this, too, accounts for their showing so little spite in action. It must also be remarked that they do not fasten their spite permanently upon any one person. Their enemies change almost as frequently as the content of their delusions, and the supposed murderer of a man's daughter may enter the room and soon win the confidence and esteem of the old man.

All this is assisted by the very evident impairment in *memory*, especially for the recent past. The details of events long past, even those of childhood, may be ready and accurate, while they may not know what day of the week it is nor whether they have seen you for some days or not. In relating past events they are apt to get sidetracked, to wander off into endless repetitions and add thereto, under the influence of delusions, most improbable and impossible inaccuracies. The *train of thought* is interrupted, but accompanied with such a very remarkable acceptance of the most absurd notions as plainly indicates very serious impairment in *judgment*. The *mood* of these patients is variable. At first they are apt to be quiet and sad, and may rarely even attempt suicide. Generally, however, they soon get irritable, fussy, and dictatory, with considerable increase in self-esteem. They grow more talkative, and when excited may become very noisy and demonstrative and talk in the most childishly obscene, profane, and insulting manner. This general elation of spirits causes them often to be a bore to the community and a trial to their friends. They run about as imaginative retailers of gossip, are sad and angry by

turns, are easily cajoled, make many confidences, and ask much advice, but follow none. Rarely they may be sad and seclude themselves for a time and refuse food, and again they may be destructive and violent.

As the general impairment of the faculties progresses, their delusions become more absurd, their emotional excitement or depression reaches wider limits, their conduct becomes more unbearable, and the necessity for suitable restraint more self-evident in the interest of all parties. The insane jealousy already mentioned reaches extreme bounds. Detectives are hired to watch the suspected parties; incriminating and circumstantial fabrications are told to the police and friends; they hear all manner of incriminating conversations, and see the guilty parties together at night. Their enemies are hounding them, have torn their children to pieces, and are just on the point of attacking themselves. It is a common thing for God to take them into His confidences and warn them of things about to happen; they hear His voice, see Him, feel His presence beside them. At times they may be so absorbed with these hallucinations as to appear indifferent to everything and slightly confused. However, no definite confusional type of the disease is so noticeable as that found in the insanity of the later epoch.

The *course* shows frequent variations, with occasional remissions, when for a time the delusions may be relegated to the background. But even then the deterioration in their natural acuteness plainly reveals the considerable degree of dementia remaining. Sooner or later the cases become hopelessly childish and weakminded. The prognosis in respect to life is good, but for ultimate complete mental recovery it is generally hopeless.

The chief factor in the *etiology* appears to be hereditary predisposition. Some have asserted that where a mental breakdown is postponed to the later periods of life, hereditary taint must be extremely weak and problematical, as it necessarily requires a very stable brain to withstand successfully the strains of early and middle life. Though cleverly urged, we have found the facts at variance with this theory. It would seem rather that, in certain favorably predisposed individuals, the normal physiological changes incident to old age set in much sooner than usual and with pathological significance on account of their hereditary instability. Of course we would not minimize the various adjuvant causes usually leading to sclerosis of the arteries and general failure in brain nutrition.

The *diagnosis* is sometimes more difficult than would at first appear. We have to separate these from the numerous cases of mild recoverable melancholias which occur at this epoch and which have been treated of elsewhere. The gradual onset, the tendency to emotionalism, the peculiarly changeable delusions, which are mostly of the persecutory order but which are not systematized and fixed against a definite object, and, finally, the serious and progressive impairment in the judgment are the chief points to be relied upon in distinguishing this affection. Sometimes these cases are classed under paranoia, but the changeability of their delusions and lack of any real attempt to pursue the object of their suspicions we consider sufficient distinctions. Their periods of moodiness, the refusal of food, and sudden violence at times have suggested to some the onset of dementia præcox. These acts, however, are purposeful rather than merely impulsive, and are evidences of increased emotionalism rather than of destruction of feelings; and, finally, the subsequent terminal dementia is of a type similar to that of ordinary feeble old age, plus delusions, rather than the blankness of the imbecile.

Naturally enough, the *treatment* resolves itself into the study of how best to make the patients comfortable and insure the preservation of their physical powers. This is best done generally in some institution, public or private, where the unexciting life and better control over the personal habits and hygiene of these patients insure less trouble and difficulty for both patient and friends, and really prolong life in increased comfort in most instances. However, many of these cases, especially after they have grown considerably demented, can often be quite suitably cared for at home if properly trained attendants can be provided. It seems folly, with our knowledge of the disease, to seek any specific for the general mental affection.

B. Senile Insanity, Proper.—Under this term we group a large number of cases in which the normal physiological involution of the faculties expected after sixty years of age has progressed to pathological limits. It has been customary with many to include under this term various cases of mental depression and exaltation which often run rather typical courses but slightly modified by the general failure. These are best considered, however, as late cases of melancholia, of manic-depressive insanity, or of circular insanity, and as such the reader is referred to them under their appropriate heads. Senile delirium might with justice be relegated to the section on confusional insanity, but as it seems to depend directly upon a rather sudden senile breakdown, it will be dealt with here in brief. We have also those cases in real old age which present a group of symptoms similar to those described under presenile insanity. These will be considered separately under senile persecution. There remain, then, the numerous cases of steady mental deterioration comprised under senile dementia, with those exhibiting a very grave form of this affection grouped together under senile confusion.

Clinically, then, there are presented: 1. Senile Dementia. 2. Senile Confusion. 3. Senile Delirium. 4. Senile Persecution.

1. *Senile Dementia.*—Senile dementia is characterized especially by the gradual onset and progress of a general mental deterioration. None of the mental faculties are at first lost; they become blunted, and this accounts for the peculiar coloring of the whole clinical picture.

Perception may be good, but the full comprehension of details is lacking. In this way their realization of time, of place, and of persons may be at fault. They get lost easily, even at home, become lacking in animation and general mental acuteness, appear stupid, sleepy, uninteresting, and uninterested. Besides the clouded *orientation*, the *train of thought* is interrupted. They cannot read with understanding nor follow a discourse; in fact, they lose the thread of ordinary conversation or do not see the point at issue. They lose their power of initiative, their creative faculty fails, they cannot adapt themselves to new surroundings or conditions, nor change their point of view. They think in a regular routine according to their accustomed habits, lose their flexibility of thought and power to change easily at will from one subject to another, do not modify their opinions nor further elaborate previous conceptions. Thus their conversation flows in one tedious round of ever-contracting ideas, which are brought in everywhere without regard to their connection or bearing. The elaboration of ideas and perceptions into new conceptions, the power of analysis and synthesis of thought, the formation of opinions and judgments are hopelessly impaired. This explains their lack of full comprehension of passing events, their proverbial "conservatism," and their inability clearly to see and withstand the delusions which naturally come to them.

Great impairment of memory is apparent, especially for the recent past. Ideas long dormant, however, may be revived, and circumstantial and detailed accounts of happenings long past are often remembered with remarkable clearness, when most important happenings transpiring to themselves or others seem to find no lodgment whatever in their brains. One will remember where he lived as a boy, who were his school-fellows, recount the details of his marriage arrangements, but be absolutely ignorant of where he is or of the fact that he was brought from his home the day before. In fact, he is apt to live wholly in the past, and mistakes his companions for his former long-lost associates. Occasionally, when defective remembrance leaves unmistakable gaps in narration, the missing links are filled in with inventions without any realization of their fictitiousness. Thus, in process of time, a well-worn favorite story, by silent elision of the

main facts and insertions, may become a totally different and incomprehensible fabrication. As the memory grows weaker, the circle of ideas narrows until the impoverishment of thought and diction is evident in their painfully monotonous remarks.

Delusions are numerous even in the early stages of the disease, but call forth no particular activity until the se-

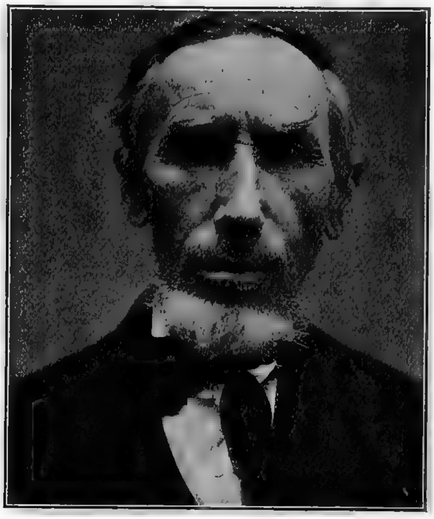

FIG. 2839.—Senile Dementia of Light Grade. Patient vigorous, neat, and orderly but deluded.

vere disturbances of the emotional life take place. At first they are wont to imagine that some evil is to befall them, or are constantly worrying about their health. This may be associated with actions and ideas of childish self-importance. A common delusion is that their food does not digest and that nothing passes from the bowels, that their enemies have ruined and killed them or left them for dead. They may even make childish preparations for suicide, and somewhat infrequently may accomplish it. Hallucinations of sight and hearing are sometimes very prominent and fantastic. They see changing colored pictures on their bedroom walls at night, likenesses of dead friends or relatives, landscapes and gardens; they hear angels, recognize their friends' voices, hear threatenings and preparations for their own destruction.

The general trend of the emotional life is toward complete blunting of the sensibilities and desires, the merely animal wants dominating their higher emotions until complete uniformity is reached. This process, however, is often marked with great fluctuations in the tide of the emotions, which, when influenced by their delusions, may cause widespread devastation and distress. The patients grow silent and indifferent, are not influenced so acutely by the pleasures or sorrows of existence, grow self-centred and more jealous of their own bodily wants, reserve their choicest blessings for any Jacob who will satisfy their hunger, bear with the fortitude of indifference even a Job's losses, but are up in arms and rebellious at the least attempt to cut off their supply of tobacco. Again, the patient's humor changes and there is evident extreme satisfaction, childish joy, and unnatural susceptibility to great fluctuations in humor. One moment he is irritable, dogmatic, and impatient; the next, for the slightest cause, he is in tears and despondency; a moment later, radiant and laughing. During these periods of elation of spirits, the passions, untrammelled by the checks of judgment and reason, are apt to run riot. This is seen in their outbursts of anger with vociferous and unbridled swearing and abuse, and especially in the increase of their sexual impulses. They often contract foolish marriages or content themselves with indecent exposure, masturbation, and obscene talk. At times they even make indecent assaults, especially upon young girls.

Gradually this mood may be more continuous and bring about for a considerable period great changes in conduct and action. Extreme restlessness and irritability are developed, they quarrel constantly with their companions, are ever working or fussing over imaginary work, talk a great deal, threaten, and sometimes become violent. They run about the neighborhood, collect heaps of trash, meet with accidents and mishaps, and are a constant trial to their guardians. At night their greatest restlessness is manifest. They get up and wander about the house, often with serious danger of setting fires, rummage around and tire themselves all out, and may be quiet and sleepy the next day. They grow neglectful of their toilet and even of ordinary cleanliness, and sometimes, if uncared for, become most distressingly filthy.

The physical changes which accompany this mental degeneration indicate a serious decline in the general health. The appetite grows poor, nutrition suffers, the subcutaneous fat disappears, the skin becomes wrinkled and yellow, with pigmented areas and spots of keratosis senilis, which may break down into carcinomatous degeneration. Occasionally there is troublesome itching of the skin—pruritus senilis. The teeth are lost and the alveolar processes of the lower jaw are absorbed, with characteristic change in its shape and consequent falling in of the lips. The muscles atrophy and weaken, the bones become more brittle, the arteries harden and are distinctly visible in their tortuous course up the emaciated limbs. The pulse grows weak and slow and is apt to be irregular. The hair becomes sparse, coarser, and turns gray, with, possibly, the exception of that of the eyebrows. The eyes grow far-sighted, then gradually get dim from clouding of the lens. Arcus senilis is common. The pupils are not infrequently contracted, unequal, and react sluggishly or not at all. The tendon reflexes are generally increased, sometimes decreased, and occasionally absent. The superficial reflexes are wont to be uniformly diminished. The voice changes gradually to a peculiar, weak shrillness or to a husky indistinctness accompanied by other symptoms of aphasia. Headaches, dizziness, hemianæsthesia, ptosis, and hemiparesis of the tongue, face, or extremities often attest the serious disturbance of brain

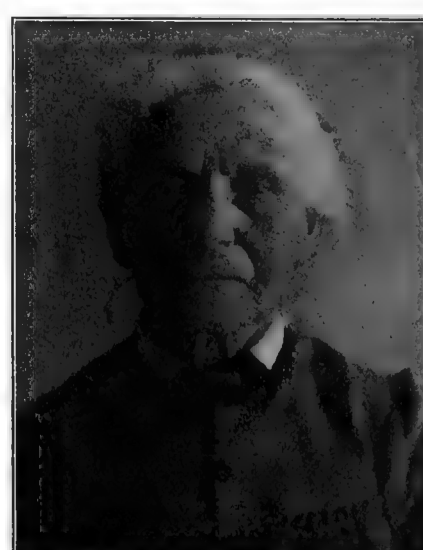

FIG. 2840.—A Second Instance of Senile Dementia of Light Grade.

nutrition. They become hard of hearing, clumsy, tremulous, and uncertain in their motions. After the onset of mental symptoms the physical signs of age are apt to progress much more rapidly, so that a patient may within

a few months look many years older than he really is. Many of these physical peculiarities were strikingly shown in the subjects of the accompanying illustrations.

2. *Senile Confusion.*—When the process of mental deterioration above described has advanced toward its final

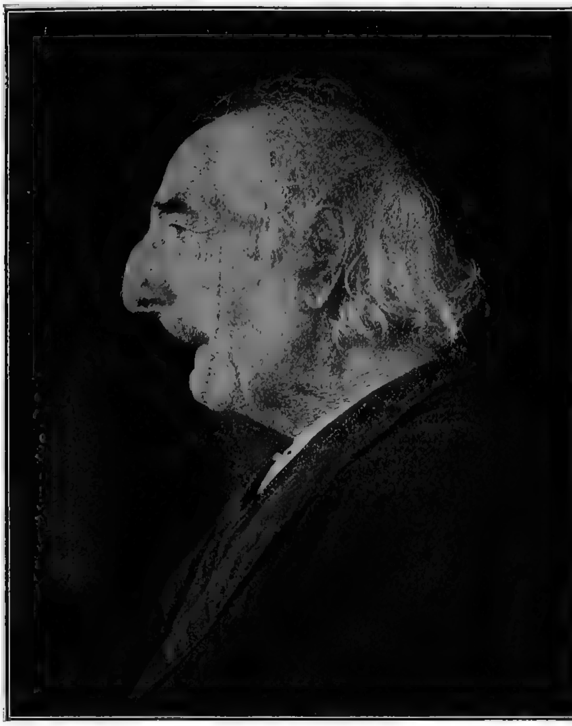

FIG. 2841.—Senile Dementia of Severe Grade. Patient feeble, careless, and untidy.

limits, we may have the picture presented of what is usually classed as senile confusion. All idea of time, place, and the recognition of their companions and relatives is lost to these patients, they do not know how old they are nor where they live, how many children they have, nor whether they are married or not. The train of thought is hopelessly disjointed. They do not seem to have any motives for action and the scope of their ideas is increasingly narrowed. Single phrases and sometimes words or syllables are often repeated over and over with senseless monotony and sometimes with a certain rhythmical cadence. There is evident, also, frequent elision of the nouns in speech or writing, and other signs of amnesic or motor aphasia.

Often fantastic delusions of grandeur or of persecution are exhibited. One old patient would stop in his fruitless hunt "for the cows" about the ward, and attempt to harangue with silly pomposity and perfectly meaningless phrases an imaginary audience of grangers. Others are depressed, with hypochondriacal, nihilistic notions—the remnants, perhaps, of a former more active melancholia. Every idea that it is possible for them to conceive is seemingly told and believed in as fact.

Hallucinations of sight are not uncommon, especially at night, and vary according to the mood of the patient. This varies constantly. One moment they are silent, morose, and woe-begone; the next, elated and childishly cheerful; and then again, suddenly, without apparent cause, are sad and lachrymose. At night they show special restlessness. They get out of bed repeatedly, wrap up their bedding and other clothing, and wish to start to walk home. They tear the sheets, smear things, and, if not carefully watched, become disgustingly filthy and destructive. Their appetite wanes and often they refuse food. They may become so weak that they cannot get out of bed for weeks or months, but pass their final days in a state of semi-consciousness or mental twilight without appearance of suffering or desire, the merest wreck of their former physical and mental greatness.

3. *Senile Delirium.*—This is really an exhaustion psychosis from a rather sudden senile breaking up, accompanied by active delusions, hallucinations, mental confusion, and generally physical collapse.

As a rule, the symptoms progress rapidly when once developed, although various lighter signs of senile degeneration may have been evident for weeks or months previously. The onset is often determined by some acute sickness, accident, or mental shock. Thus we find it following rather abruptly the partial convalescence from la grippe, summer diarrhœa, a fall or blow on the head, apoplectiform seizure, or more rarely from bad news or worriment.

Within a few days or weeks the consciousness of the patients becomes completely clouded. They do not recognize their friends nor realize what is going on about them. There is no continuity of thought, but entire irrelevance and incoherence of speech and action. They may not know whether it is daylight or darkness, whether they are hungry or have just eaten, neglect the calls of nature, may soon pass into great motor restlessness, and rapidly sink into lethal exhaustion.

In their talk they manifest frequent aphasic disturbances—especially the elision and slurring of words, the unintentional gaps in meaning, the naming of objects wrongly even when corrected. Multitudinous delusions are evident, sometimes of a persecutory or sad character, but often of a grand or joyful content. They are poisoned, bewitched, about to be hanged, torn to pieces, castrated, or set up as a target. Their children have been destroyed, there is no hope for mercy, they are eternally

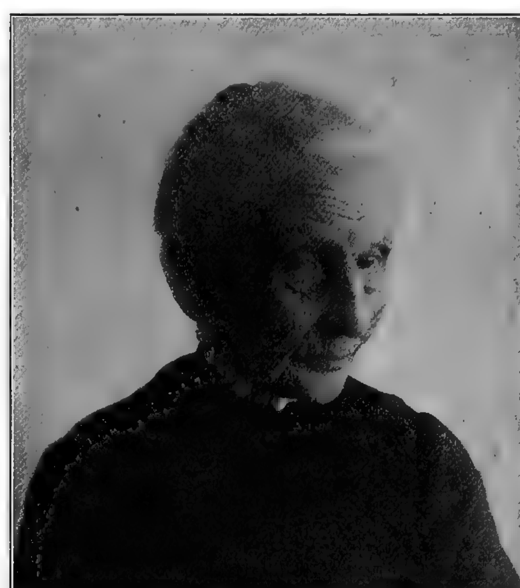

FIG. 2842.—Another Case of Senile Dementia of Severe Grade.

lost, are too bad even for Satan's care. They hear loud calls and reproaches, singing, threatenings, hear their scaffold being built, see knives and swords, poison in the food. All these ideas are not told about soberly; they are rather inferred from their disconnected utterances and from their actions in trying to avoid the consequences feared. In fact, their talk may degenerate into mere meaningless sounds and senseless repetitions of the same sounds (echolaly). The mood of the patients is usually depressed and worried, but may become calm and serene or joyously happy. There is almost always great motor

restlessness, especially at night, no inclination to go to sleep, but a constant nervous tension and desire to go away, break out of the window, tear the sheets, scream, bite, and scratch if hindered. Later, they weaken, creep

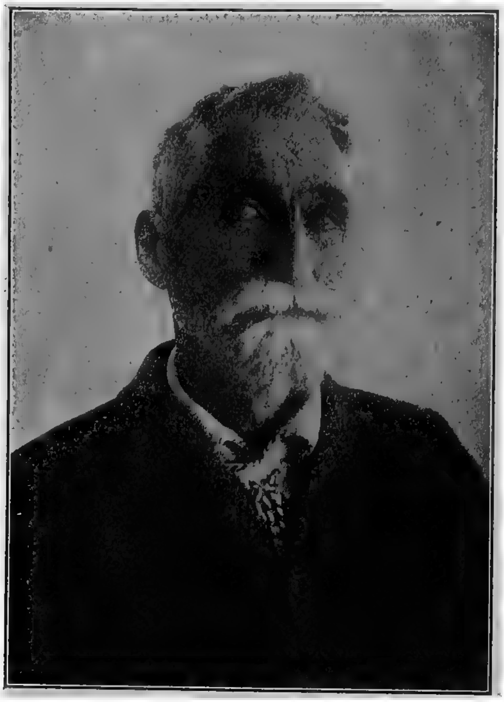

FIG. 2843.—Senile Confusion with many Hallucinations and Delusions.

about on the floor, smear themselves in every way, roll about, and object to and oppose everything that is tried to be done for them.

Under this head should be included the "dark-room delirium" so often observed after cataract operations in the aged. Here, however, hallucinations of sight are apt to be uppermost, the talk more sensible and connected, and the motor restlessness not so marked.

The duration of senile delirium may vary considerably, with many repeated remissions and relapses throughout its course. Sometimes these cases may eventually, with careful treatment, make a very good recovery, but as a rule it is at best partial, and finally leads to grave dementia. Those cases that do prove rapidly fatal, and they are not uncommon, show more and more confusion and continuous excitement, their strength fails rapidly, they do not assimilate the food they are forced to ingest. Then there ensue semi-consciousness, picking at the bed clothes, subsultus tendinum, extreme emaciation, weakness, profuse sweatings, deglutition- or ether-pneumonia or some other accident, and death.

4. *Senile Persecution.*—This group includes a number of those cases which exhibit symptoms analogous to those described under presenile insanity, among which various delusions of persecution are continually uppermost in the downward progress to complete dementia. The onset is gradual, with usually a change of mood and habits. The patients grow quiet, morose, suspicious; seclude themselves, and, finally, become definitely deluded and it may be actively hostile. They think they are robbed, insulted, intentionally and slyly poisoned, that their income has slowly been taken away. They hear threatening voices calling to them. They are charged with electricity, wet with corrosive acids, shot at and perhaps killed many times a day. Sometimes they become markedly elated, deck themselves, and put on airs.

The general conduct of these patients is good, they keep neat, and to a casual observer seem no different from normal old persons. At times, however, under the influence of delusions, they become more irritable and troublesome. The train of thought is not early impaired, nor the recognition of persons, places, time, and the general events of their environment. They often cause much trouble to themselves and others when at large, but under proper guardianship and restraint they usually pass a fairly comfortable and quiet existence to about the normal limit of life. In all their delusions there is a marked and growing childishness and absurdity, their persecutory ideas are ever changing and not much elaborated, they are easily influenced to modify their opinions, and in many ways show that the essential process is the gradually progressive dementia.

ETIOLOGY.—Doubtless all the factors causing the onset of the peculiar symptoms which we designate as senile are not yet appreciated. Some, with an imaginative tendency, have urged the auto-intoxication theory as explaining the origin of the more or less sudden nervous breakdowns. From the analysis of large numbers of cases it has been determined that the onset in the majority of instances occurs in the decade between sixty-five and seventy-five years of age, and that in those whose mental breakdown is noticeable earlier than this there has usually been much overwork, worriment, or excesses of various kinds in early life which have tended to predispose to premature decay. Heredity, we believe, plays a far larger rôle as a predisposing causative factor than is commonly supposed or can be learned from statistics, for the reason that there are usually but few who can tell accurately concerning the inner family life of the relatives and ancestors of old people, as most of the close friends have already died. We

FIG. 2844.—A Second Case of Senile Confusion. Patient died at the age of one hundred and four years. The photograph was taken when she was ninety years old.

know, too, how difficult it is to learn accurately the family history even in the case of young people. As a matter of fact, a definite history of hereditary mental taint is found in not much over fifty per cent. of the cases, except, perhaps, in those which we have included in the presenile group. Quite a number of these patients have had the reputation of having been rather weak-minded all their lives. This was the case with the subject of Fig. 2841, who soon became unmanageable from his extreme irritability when senile symptoms began to manifest themselves after the age of sixty years.

Frequently there is the history of a rather acute onset

after severe physical injuries, especially to the head, after grave general diseases accompanied with considerable rise of temperature, as in typhoid and influenza, or after violent excitement or severe nervous shock. This last seemed to be the determining factor in the case of Fig. 2839, who never recovered his mental balance and composure after being attacked in the woods by a frenzied Frenchman with an axe. Finally, it may be said that any factor tending to produce those subtle changes in the arteries which we speak of as atheromatous and calcareous degenerations, would indirectly thereby hinder the nutrition of the nerve centres and predispose to senility.

Pathology.—Macroscopic examination of the brain shows evident destruction of nervous tissue, with consequent loss both in volume and weight of that organ. The space thus available within the skull is filled up by compensatory thickening of the skull and by collections of serum. The average loss in weight has been estimated as nearly half a pound. The general contour may not be noticeably changed, although such brains are apt to be much softer than normal. Sometimes distinct calcareous or atheromatous patches may be evident in the larger arteries, and less frequently minute capillary hemorrhages and aneurisms or larger areas of softening, especially in the region of the basal ganglia. The pia is white, opaque, and thickened in patches. Infrequently there are adhesions of the dura; sometimes hæmatomata may be noticeable. Throughout the body we frequently see the results of the general hardening of the arteries—organic lesions in the heart and great vessels, and in the kidneys.

Microscopically there is an evident thinning of the cortex with atrophy and destruction of the parenchymatous elements and subsequent sclerosis and increase in neuroglia cells. Pigmentary degeneration is frequently noticed. The acute changes in the cells incident to sudden failure of nutrition are often also to be seen.

Diagnosis.—The boundary lines between slight forms of senile dementia and normal old age are not sharp and well defined, and in certain cases the judgment as to their presence or absence must be purely arbitrary. The grave emotional outbreaks, and more certainly the cropping up of delusions in other cases, may soon make the diagnosis more certain. Much the same hazy boundary lines lie between these cases and those belonging to the involutionary years and presenile periods. In cases of melancholia the onset of senile symptoms is coincident with a growing tendency toward hypochondriacal and nihilistic delusions and an evident increased emotionalism. From general paralysis the diagnosis would seem not difficult, but, as a matter of fact, frequently mistakes are made between these two diseases. The excitement and delusions of grandeur may be quite similar, but the paralytic is more prone to enter cheerfully into minute details and be less impatient and irritable than the case of senile excitement. The accompanying physical signs would also be of eminent value.

The forms of senile persecutory insanity may be mainly distinguished from true paranoia by the general mental weakness, the disinclination to further elaborate their delusions and act accordingly, and, finally, the almost entire lack of true systematized delusionary plots. From the similar cases included under presenile insanity there would seem to be no strict boundaries. In the later cases, however, there appear less marked emotional periods with an increasing general mental failure.

Prognosis.—True senile dementia is never fully recovered from. Under appropriate conditions there may be marked remissions, decrease of emotionalism, and a generally calmer habit of mind sufficient to enable the patient to return home to spend the rest of his days in a quiet, dreamy, second childhood. On the other hand, the onset of confusion may lead to accidents and no end of trouble if the patients are not closely watched and cared for. Abject helpless dementia seems to offer no ray of hope for even temporary clearness—the mental fires have burned out and nothing remains but the whitened ashes. As before stated, the presenile forms may exhibit almost complete restoration, and may even afterward re-engage in many of the activities of life. The great majority, however, of all these patients eventually become more and more markedly weak-minded, until they are carried off by some sudden intercurrent disease.

Treatment.—*A. Prophylaxis.*—Little stress has been laid upon this aspect of the subject by writers, obviously because, when the signs of dementia first appear, the sclerosis of the arteries and other grave pathological changes have already progressed considerably and certainly cannot be prevented; only occasionally can they be hindered, and still more rarely stopped by means of treatment. There are so many persons, however, in the community with slight nervous symptoms in earlier life sufficient to cause the experienced clinician to suspect their brains as offering a suitable soil for the involution insanities, that a few words in this connection may not seem amiss.

In such cases the regular habits of life, plain nutritious and unstimulating food, exercise, and the avoidance as far as possible of all worriment and severe mental or physical strains considered so important in the care of the really sick, will be found more beneficial in preserving the mental equilibrium than in restoring it when once disturbed. Many times if business men would be satisfied with a competence, and would retire from the wear and tear of exacting work comparatively early in old age, as has been so shrewdly recommended of late by a prince of finance, many would undoubtedly escape the untoward effects of senescence who now yearly hopelessly break down. Particular care to avoid excitement and the adoption of measures likely to hasten convalescence from acute physical disease in the aged will often prevent severe and sudden mental collapse. For similar reasons, operations that are so frequently recommended in old persons "if the heart is all right," should always receive due consideration as to the mental risks which may be incurred.

B. General Treatment.—The first requisite in caring for the aged insane is to secure good, careful, conscientious attendants. For this reason, relatives often make the best nurses, contrary to the usual rule in mental diseases. The whole daily life of the patients has to be mapped out and regulated. While diversion is ofttimes an object, it must be borne in mind that the old are very conservative and enjoy old haunts and familiar habits of life better than constant change of companionship and scenery. It seems sad and incongruous sometimes to find some old home-body forced to travel and see new faces and scenes in the hope that her mind may be diverted from the introspective ideas of beginning involution.

On the question of diet we would not be dogmatic. If everything that has been recommended as allowable were to be taken, there would be no restriction; if everything objected to were cut off the list, the patients would undoubtedly starve or die of thirst. It seems absurd to me to withhold such staples as bread, milk, and spring water from these often very delicate, toothless old people, because, forsooth, there may be a proportion of lime salts contained in each that is supposed to increase the arterial deposits. Yet such a course is advocated by the very latest authority upon our shelves. The various prepared foods upon the market have proved very efficient in feeble cases. As a general rule, all the food and drink should be served warm or hot. The living rooms of the patients need to be light and well ventilated, and kept warm both day and night. Efficient night attendance, especially with those who are restless or confused, is imperative. Cleanliness must be insisted on. For this reason the rooms are often best rather scantily and plainly furnished, with guards to the windows at night if necessary. Outdoor exercise in moderation quiets excitement and tends to produce more natural sleep, as do also massage and warm baths in certain cases.

C. Special Treatment.—Attempts to modify the degree of dementia by specific medication have uniformly proved unsatisfactory. Usually such remedies as will assist the general attempts to increase the physical nutrition will be found best. Potassium iodide has been lauded by some

for its specifically alterative effects in this disease. On the whole I have been disappointed in its use. On the other hand, cod-liver oil in as large doses as the stomach would bear, has proved much more efficient. In emaciated individuals rubbing with quantities of *pure* lard or other animal oil has seemed at times to decrease the dry harshness of the skin and markedly increase general nutrition.

For the noise and restlessness opium should not be used. In fact, it has but little place in the insanities of old age. After extensive use of all the newer sedatives, I believe that dormiol, in appropriate doses, is the most generally serviceable. From two to four drachms of the ten-per-cent. solution of this drug in water will usually be found sufficient, although such doses can be safely repeated if necessary. It does not seem to depress the circulation appreciably. Small doses induce a calmer frame of mind during the day, and larger ones will quickly produce dreamless and restful slumber at night. Its effects are transient and it is easily taken, and has no disagreeable effect subjective or objective. Sulphonal and trional are serviceable on occasion, but chloretone has proved disagreeable and is too depressing to the heart to risk in most cases. In patients manifesting extreme weakness or collapse, complete rest in bed and vigorous stimulation with alcohol and nux vomica and warmth are sometimes the only things which will avert a sudden dissolution. I have always been singularly unfortunate in the use of digitalis in these cases and I believe that a special watchfulness is needed with this drug in senile delirium and collapse. For continued refusal of food the use of the stomach tube is invaluable. The patient must not be allowed to starve himself too long before this measure is resorted to. In vigorous individuals it has been my custom to feed after the second day's abstinence, but in debilitated cases we must not wait for so long a time. In feeble cases I have found that the introduction of the nasal tube seemed to cause more discomfort and in many cases to set up more disturbance of the mucous membrane than when the tube was introduced through the mouth. In all such cases very great care is to be taken not to get the least amount of liquid into the trachea, on account of the danger of insufflation pneumonia and a rapidly fatal termination of the case.

The question as to whether a patient would be better off in a hospital or asylum or at home has to be settled according to the character and station in life of the individual case. The milder types can very comfortably be cared for at home. Many of these cases, even, when their circumstances will not allow of constant and intelligent supervision, are undoubtedly better off in a well-managed hospital, while even quite severe cases can avoid the stigma of the asylum if they can command trained attendants or the facilities afforded by the private retreats and sanatoriums so numerous throughout the country.

Albert Edward Brownrigg.

XVII. INSANITY, CLIMACTERIC.—The normal signs of the menopause are largely confined to nervous and mental change of a minor kind, and are present in varying degrees in most women. At the ordinary menstrual periods the susceptibility of the nervous system to various even slight stimuli is considerably increased. Many women—it is well known—are at these periods unduly sensitive and inclined to be irritable and dispirited. They are also more or less whimsical and lose their control over slight occurrences.

At the climacteric, however, these or similar manifestations, even when not intensified, are especially prominent because they are attended with increased frequency and unusual abundance of the uterine flow in many cases, and because of the length of time elapsing before complete cessation of the menses takes place.

Although the phenomena which characterize the menopause are chiefly of the nature of slight mental or nervous disturbance, actual insanity in the form of a first attack and directly and solely attributable to the menopause is far from frequent. It would seem as though the relatively limited and special nature of this change precluded to a great extent the possibility of profound mental disturbance, and was perforce confined to a set of less pronounced disorders. Sutherland believes that mental trouble amounting to actual insanity is extremely rare at the "change of life." Merson,[1] whose monograph on this subject is very thorough and exhaustive, considers that the histories of the cases which he has investigated point to the conclusion that the menopause is not of itself the immediate cause of their insanity. Mitchell[2] is convinced of the fallacy of attributing melancholia to the menopause, and his statistics show that of all insanities but two per cent. are due to that cause. Lewis' ratio is 4.4 per cent. Statistics on this point are, however, widely divergent, and there is little room for doubt that the number of cases of true climacteric insanity would have been smaller and the percentages more uniform if the cases selected had been invariably and exclusively confined to those which originated during the actual progress of the menopause and were uncomplicated by other causes. This inaccurracy does not prevail in reporting cases of puerperal insanity, the starting-point of which is always shown to be within the parturient period. The apparent laxity is probably in a measure due to the difficulty that exists in ascertaining the first appearance of the menstrual irregularity which marks the menopause. Although, as Clouston[3] truly remarks, the mere cessation of function does not necessarily fix definitely the mental and nutritional changes that mark the period, and that therefore the mental disease that accompanies the climacteric need not be coincident with the menopause; nevertheless the more remote the attack is from the menopause the more room will there be for the operation of other causes, and there are a multitude of morbid influences—mental, moral, and physical, direct and indirect—to which women are exposed at this time of life.

Attacks of recurrent insanity at this period have also served to swell the number of cases of "climacteric insanity" in tables of statistics. They are obviously of much earlier origin, as a rule, and should be rejected from this category. Finally, competent opinion as to the baleful effect of this physiological change with regard to disease in general has greatly altered in the last twenty years, and the menopause is no longer looked upon as an experience fraught with peril and difficulty.

We can therefore only say, as regards the relation of the menopause to mental disease, that it may be the final factor in the causation of attacks of insanity in occasional cases in which a bad heredity with or without other influences has been previously inoperative.

The menopause is, however, quite an effective influence in cases of insanity with a history of previous attacks. In other words, when the heredity taint is marked and previous attacks of mental disease have been undergone, there is reason to fear that the menopause will give this tendency to mental disturbance an increased activity which will be sufficient to precipitate a relapse.

Nevertheless, although the influence of the menopause itself is a minor one in this direction, there is a general and recognized condition of the organism which attends middle life in both sexes, and in which the period of the menopause is included, that is charaterized by diminished vigor of body and mind, lessened interest and ambition, perhaps unnecessary anxiety, and a tendency to become more easily disturbed than usual. It is due to the failure of the system properly to adapt its powers to meet changed conditions or increasing demands on its resources. This period, which represents an involution of the mental faculties, begins earlier in women than in men, being probably hastened by the menopause, which in turn aggravates the condition. This soil is a most fruitful one for mental disease, especially in the hereditarily predisposed. By far the most frequent form that it assumes is melancholia, which may be of any grade. This—the melancholia of involution, as it is termed—embraces most of the melancholias except the depressed states occurring in the course of dementia præcox and organic dementia, and properly includes nearly

all cases designated as "climacteric insanity," for which few writers have ever claimed distinctive mental manifestations and in which ordinary melancholia has always been found to be the prevailing condition. The limits of melancholia of involution as given by Kraepelin [4] are from the fortieth to the sixty-fifth year, sixty-four per cent. of the cases occurring between fifty and sixty. For a full consideration of this important form of insanity in all its relations, the reader is referred to the article on *Insanity: Melancholia,* and for certain allied presenile conditions to that on *Insanity, Senile.*

Although melancholia is the usual mental state at this time of life, several others are not infrequently met with. The peevishness, ill-temper, and ungovernable anger of previously amiable and reasonable women occasionally amount to a condition resembling "moral" insanity. Sudden repugnance to the dearest members of the family has led women at this time to tyrannize over and hate others of the household and even to desert their husbands. Primary delusional insanity is not uncommon, and paranoias heretofore latent are apt to crop out under the stress of this period. The simplest type of these conditions consists in systematized delusions of persecution without necessarily any defect in intelligence (Berkley). A craving for stimluants may manifest itself possibly through a desire to meet or appease the anomalous sensations at the epigastric region so common in women at this time. Tilt, like B. de Boisment, has several times seen temperate women have a craving for spirits only at the menstrual epochs, the craving subsiding with the flow, and the same desire has been noticed in pregnant and puerperal women. Esquirol and St. Royer Collard, quoted by the same author, had met with women in good circumstances, who all through life had been temperate, but who at the menopause were suddenly seized with an irresistible desire for brandy, which again became disagreeable to them when the critical period was passed.

The *prognosis* of all mental disturbance occurring during the period of general involution is good, as a rule, in uncomplicated but acute cases. The duration, however, is somewhat longer than that of insanity occurring at other times of life, owing to the protracted nature of the physiological change underlying it. We should, therefore, be less surprised to find no evidence of improvement under a year than in other cases of insanity which terminate favorably.

The *treatment* should be adapted to the form of the insanity that the disorder assumes, and the reader, is, therefore, referred to the special chapters describing them as well as to that on the General Treatment of insanity.

Henry R. Stedman.

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XVIII. INSANITY: MELANCHOLIA.—The term melancholia has been applied to all forms of mental disorder in which a morbid depression of feelings dominates the clinical picture. Besides emotional depression, a more or less pronounced retardation of mental processes was found in certain cases, and some authors regarded this symptom (under which, however, a number of heterogeneous phenomena were comprised) as an important part of all melancholias and included it in their definition. Hence it came about that not only depressions, but some states in which the emotional element was more in the background or absent, while the retardation of mental functions was the only or the most prominent symptom, were also described as melancholias. The frequency with which conditions of "melancholia" occur; the fact that with the depression we often find associated other apparently heterogeneous traits; the circumstance that some depressions clearly form merely a phase of a disease which may also manifest itself in other phases; moreover the differences in course and outcome, the variations in causes—all these considerations have given rise to the conviction that melancholia is by no means a disease entity or an adequate clinical group.

This has been recognized more or less clearly by many writers, and has led to many groups of melancholia and to various conceptions in regard to these cases. It would lead us too far to trace these changes in the history of psychiatry, nor can we give any space to the divergent views of the present writers, but have to limit ourselves here to what seems to us a fair presentation of this difficult subject and one which tries without dogmatism to be just to the facts as they present themselves.

We have in the foregoing spoken of the lack of agreement which exists among different writers on melancholia, as on every other mental state. This lack of agreement is primarily due to the fact that the principles according to which groups of melancholia were and are made, differ so widely. Frequently the differentiation has been made according to some striking feature in the clinical picture without consideration of finer traits, or, of course, outcome, etiology, and whatever other data may be at our disposal. The only exception is represented by the melancholias of general paralysis—here all these points were considered and it would probably be difficult to find a psychiatrist who would speak of a general paralysis which is complicated with melancholia; although the various depressive states which occur in this disease still deserve further study. While we are in a less favorable position in regard to other depressive states, we should nevertheless proceed according to the same principles which have been used in the depressions of general paralysis. Kraepelin has pointed out that a certain number of melancholias belong to the domain of manic-depressive insanity. We have, in a preceding section, given the characteristics of these, and have seen that they show no essential tendency to deterioration. There are other depressions, in the young chiefly, which show such a general tendency, though the outcome in dementia seems not inevitable. The more we observe these cases the more we find that they also show certain symptomatic characteristics. It matters little what we call these—Kraepelin has united them together with various states of excitement, as well as with paranoiac states under the head of dementia præcox. Whether the pictures thus included form in reality an adequate clinical group need not be discussed here. I am personally inclined to doubt it. Nevertheless we may agree that there exist certain depressions in the young which show a tendency to deterioration. These pictures are by no means uniform, but this is not the place to describe them, and the reader must be referred to the chapter on dementia præcox, as well as to the differential diagnosis of manic-depressive insanity, for an account of their characteristics. We have thus far mentioned the melancholias of general paralysis, manic-depressive insanity, and dementia præcox, three groups of psychoses in which other syndromes occur as well.

But states of melancholia are also found associated with other conditions such as various "somatic diseases." In some cardio-vascular disorders we may find depression with fear and delusions of persecution, even hallucinations. Focal lesions of the brain may be followed by depressions. Alt has described an acute psychosis with fear in dilatation of the stomach. Moreover, Graves' disease and myxœdema may give rise to "melancholia." Finally, the neuroses, hysteria and neurasthenia, may be associated with depressions; even epilepsy presents certain pictures in which depression is very prominent. It would lead us too far to go into the symptomatic characteristics of these various states, nor are many of them studied with sufficient clearness to permit of a distinctive description. It is of course not excluded that such diseases may be complicated with a psychosis in which states of melancholia exist. But usually the depression seems to be a manifestation of the disease. We see from this that emotional depression is a not infrequent accompaniment of various diseases.

But after all these depressive states are excluded there

still remains a large class of melancholias which do not seem to belong to any other group; in these a melancholic syndrome is the only manifestation of the disease. The bulk of these cases occur in advanced years and have by Kraepelin been called "involution melancholias." It is these which we must more particularly consider. But in earlier years such melancholias also occur; some of them resemble certain forms of melancholia of advanced years; others are simple depressions usually with a favorable outcome. All these require further study. They are not of very frequent occurrence. We must also admit that in regard to melancholias of advanced years, it is by no means clear that all the cases here included belong together. It is seen from this that the question of melancholia is still a difficult one. But the fact that these difficulties are recognized, and that "melancholia" no longer represents a clinical group, is of the utmost importance for practical as well as for scientific purposes.

It should be stated, in order to convey a correct idea of the proportions, that besides the depressions in the young which form a part of the provisional group of dementia præcox, those of manic-depressive insanity and those occurring after the climacterium and belonging to the group to be described, form by far the bulk of the cases which we see.

The conditions included in the group of involution melancholias, which will now be considered, all present, after a more or less protracted prodromal state, the melancholic traits of depression of feelings; and in most cases apprehension and fear play a more or less prominent rôle. As a result of this depression and fear we find almost always delusions of self-accusation, of poverty, of impending danger; sometimes the delusions may become very absurd. In a certain group delusions of a somatic character are most prominent. Anxious restlessness is very common. In most cases the patients are clear, and though the mental horizon may be more or less narrowed to the depressive ideas, and a certain insufficiency of thinking may be present, this seems usually to be in harmony with the emotional disorder or to be the beginning of the permanent deterioration. A fair number of patients recover, others deteriorate, but it has not been possible to lay down a definite rule, and say which type of cases have a bad prognosis, although practically it is at times possible, even fairly early, to recognize the permanent damage. The degrees of deterioration differ. The chief character of the deterioration seems to be a loss of energy, going often with the feeling expressed by the patient that his strength, his interest, his mental power are gone; this loss of energy expresses itself in a diminished activity. The mental horizon becomes narrowed; a more or less pronounced mental insufficiency becomes evident; certain traits of the acute psychosis almost always persist; while the emotional reactions become shallow. Sometimes the deteriorations are more severe. But in contradistinction to senile dementia the memory suffers comparatively little, and what loss may exist would seem more the outcome of the narrowing of the mental horizon and of the mental inactivity than of a fundamental memory defect; for, even in comparatively profound degrees of inactivity, we may often be surprised at the readiness with which, compared with what is observed in senile dementia, events are remembered from day to day. In many of these cases it has been the custom to speak of chronicity rather than of deterioration, but it seems impossible to draw a line between the two states. In the gravest forms of deterioration we may question whether we are not dealing with transitions to senile dementia; but the fact that the great bulk of these melancholias shows an absence of the characteristic memory defect, and of the characteristic progression of symptoms; together with the fact that many of the cases, though they occur in the involution period, develop at a comparatively early age, would seem to indicate that we are here dealing with different conditions. The clinical pictures as well as the forms of permanent defect will be brought out more clearly in the more detailed description of patients.

The bodily condition always suffers in these cases: the body weight may fall considerably, the appetite decreases, the tongue may be coated, constipation is very common. The sleep is regularly interfered with. The temperature is often subnormal.

As the most important factor in etiology we must mention the age of the patient. Not infrequently the menopause seems in women to form the starting-point for the psychosis, although of course this period seems to favor the occurrence of other psychoses as well. In general it seems that the entire involution period furnishes certain conditions which are especially favorable for the development of these cases. Of the nature of these conditions we are ignorant. The cases occur between the ages of forty to sixty, and even later. Arteriosclerosis does not seem to play an important rôle: it may be present in the cases occurring in advanced years; in the younger ones it is usually absent. Besides the period of life, emotional causes are of importance; one is certainly struck with the frequency with which some mental shock or some bereavement precedes these melancholias. Heredity, on the other hand, is much less prominent than in other psychoses. The duration of the sickness varies from a few months to one or two years in the non-deteriorating cases. Recurrences may unquestionably be met with. Death results from exhaustion or from some intercurrent disease. It seems that the condition which Adolf Meyer described as "central neuritis" is more apt to occur in these than in other conditions. The danger of suicide cannot be too much insisted upon.

The pathological anatomical findings are still meagre. But Alzheimer has described a fibril production of the neuroglia in the deeper layers of the cortex, a finding which I can corroborate.

The mildest conditions may be illustrated by the following case: The patient (Case I.) was a man fifty-six years old, without any signs of arteriosclerosis or senile habitus. Two years previously he had, without cause, a short depression which is said to have been very similar to the later attack, but which lasted only a week; however, a deficient sleep remained. In May, 1898, he began to worry unduly about the illness of his daughter, then about various rheumatic pains of his own; he exaggerated their importance and became restless. His worry extended to his business, yet he was able to attend to it until two months later, when the depression deepened. He thought that owing to mismanagement of business he was going to lose his money, that he would be sent to the poorhouse, and that his daughter would not be provided for. He spoke of suicide but made no attempt. He walked about restlessly, picked at his finger-nails, complained of a "restless feeling" in epigastrium and head, but showed no very marked signs of fear. He was afraid something was going to happen, in what form he knew not. He was clear, though at the height of his agitation he could not apply his mind well. He showed no other delusions, and three months after the onset of the more severe symptoms he had completely recovered.

In other instances the restlessness, which has given to many of these cases the name of agitated melancholia, and which is often the result of apprehension and fear, is not at all present or only slightly marked; again, in others it leads to intense agitation with great fear which is manifested in the facial expression, the wide-open eyes, the dilated nostrils, the rapid respiration. The fear sometimes increases as night comes on. Sometimes this fear does not fasten itself on anything; more often it results in certain ideas. The patient thinks that he is going to be arrested, killed, or torn to pieces; and then frequently accidental utterances or occurrences are interpreted as confirming these ideas, or unquestionable hallucinations may occur (usually of hearing, rarely of sight, in these milder cases).

It is seen from the above that there are cases in which the fear is evidently primary, without any delusions of self-accusation preceding it; and the fear which is often referred to the præcordium, epigastrium, or head, may not fasten itself on any idea and may constitute the first more pronounced symptom. In other instances the

depression with self-accusation seems to exist primarily, and only a few apprehensive ideas seem to arise secondarily. Then the restlessness is often not in evidence, and the picture is more dominated by a certain gloominess. These patients may complain of "not having lived properly," "not having gone to church enough," of "not having been honest in business," of "having lost their souls," of "having committed the unpardonable sin," etc. With this, as was stated, may be associated some apprehensions as to the welfare of those dear to him or even as to his own welfare. It does not seem possible to separate these two sets of cases, and probably the two emotional states are not fundamentally different. In general it seems that at present a differentiation of depressions is not possible on the basis of the kind of emotional disorder, but only on the features which accompany it.

Sometimes the delusions take absurd forms; thus, a man, forty-eight years old (Case II.), stated that he was going to be put in a cave in Wachusett Mountain to be devoured by a snake, that the United States and England had combined to arrange the cave which had been lighted by electric lights. At the same time he affirmed that there he was to live forever. He was clear mentally, showed no insufficiency in thinking, and never lost his bearings. Night after night he asked with evident fear whether he was going to be taken to the cave, and had some hallucinations of hearing which confirmed him. This patient also recovered after a year, although frequently the absurdity of the delusions speaks for a bad prognosis. But while these patients not infrequently recover, deterioration or chronicity is always to be feared.

Thus, in a man of fifty (Case III.) a condition which was very similar to that of Case I. deepened into a persistent gloom with marked loss of energy and inactivity, and a certain narrowing of the mental horizon. He retained no special delusions, his memory remained good, and there was no marked loss of judgment. On the other hand, hypochondriacal ideas may be added to the above picture of deterioration and persist in unaltered form. The patient may claim that he has no movements of the bowels, is starving to death because he cannot digest (though he may be growing stout), etc. These ideas are reiterated whenever the patient is seen, and they form almost his whole interest. Or other delusions may be retained,—either merely ideas of self-depreciation, or ideas of an apprehensive nature. Thus, a woman at fifty-eight (Case IV.), who started with a picture chiefly of self-accusation and poverty, retained persistently the delusions that she was going to be chopped to pieces, that the head was going to be cut off, but that she could not die, and was going to be a living lump of flesh, etc. These ideas she uttered without any decided show of emotion, as is very frequent in these cases. In other instances the ideas are more absurd. Sometimes renewed attacks of restlessness and fear may be repeated for years.

It will be noted that all the cases thus far mentioned remain clear during the active stages, as well as during the state of deterioration. On the other hand, the deterioration may be more pronounced, this being especially true of cases in more advanced years. The following case may illustrate this, as it also shows that the restlessness may persist for a long time. A woman of sixty-nine (Case V.) was, since the death of her husband, six years previous to the onset of marked symptoms, somewhat nervous. After the death of her sister, two years later, she was apt to complain much of various ailments, little things in the household worried her more easily, and she often cried. Six months later she began to be afraid to be left alone, and soon to fear that her only daughter would be kidnapped. The condition observed at the hospital was this: she was restless, showed distinct fear, "an operation will be performed," "If I get into that bed I won't get out alive"—"I will be cut up." She could not be reassured—"for all that I have my fear." As an occasional idea she spoke of the daughter being shut up in the hospital. Sometimes the restlessness became very marked. The memory was good, she could apply her mind well, and had her bearings perfectly. Then the ideas about the daughter became more prominent. "She is to be married to a Mormon"—"I saw him outside"—"She is to be killed"—"The food is the flesh of my daughter," etc. At the same time it was more difficult to attract her attention, her orientation became deficient, her answers to simple tests of calculation or common knowledge poor. The moaning became more stereotyped and after six months her condition became stable, and has remained so for two years. She constantly walks up and down, often rolls her body in a swinging motion, or in a peculiar manner jerks her head back with uninterrupted moaning of "no, no." She answers no questions, refuses food, and, as is characteristic in some of these cases, blindly resists every measure. Occasionally she brightens up a little and is quieter, but shows very poor grasp on her surroundings, speaks of her mind being weak, although she remembers fairly well from day to day during her rare short periods of comparative clearness.

In some cases the mental insufficiency and the poor grasp on surroundings are present even earlier and, as it were, set in almost with the beginning of the more active symptoms. This seems prognostically unfavorable. Thus, a woman of fifty-nine (Case VI.) with a slight depression, who had been in a sanatorium for non-insane, and who came to this hospital soon after the onset of more pronounced symptoms, could on admission give only poor answers in regard to her life, her surroundings, the time of the year, or to calculation tests and the like. Often she said, "My mind is weak." Her utterances were very stereotyped, the extent of her ideas being "cannot pay bills"—"will be sent to jail"—"filled up"—"cannot take the responsibility for all these people"—"the food is thrown away." She was restless and moaned. Later, her throat, feet, and jaw "are broken." She now lies in bed in an apathetic manner, untidy, tube-fed, never speaking, only pointing to her throat. She takes little notice of anything, sometimes moaning, often silent.

In other instances the delusions soon assume a fantastic character. Thus, a woman at the age of fifty-five (Case VII.), whose psychosis started with self-accusation, soon began to get restless, saying that the people at home were dead, that the water had been poisoned, it was her fault, etc. Later, she spoke of the hospital as a prison built by the Catholics in which to punish her, again "everything here is pretended," one old woman "is a dummy who is made to walk around and made to speak"—"there are no water-closets"—"nobody eats except myself"—"the letters are not from the persons they are claimed to be," she has "no friends"—"all are dummies," she is "the only woman alive." Or, again, she is "only a talking machine." "The country is in the hands of Spaniards," the physician is "the king of this country." She is "the cause of it all." "There is no sense in the papers." "Time is counted differently"—"everything is upside down"—"changed." She pinched persons about her to see if they were real. Sometimes when asked more especially about the origin of her ideas, she would say these ideas "came to her."

This case brings out to some extent what the French writers call délire de négation, a symptom present at times in these conditions.

As the oncoming deterioration seems at times to be indicated by a diminished emotional reaction to the delusions, so do we find cases in which from the beginning a shallowness in this respect is prominent. Delusions of depressive character, often very absurd and poorly founded on flimsy grounds, are uttered by the patient with remarkably little show of emotion. These cases are, so far as recovery is concerned, prognostically bad.

Finally, a small group of cases in which the somatic delusions play an especially prominent part should be mentioned. They are cases which are especially apt to occur in women directly or soon after the menopause, though cases occurring later may be seen.

Often the somatic delusions are, after a prodromal stage, the first symptom to appear and thenceforward dominate the clinical picture. Fear often seems not to

exist in these cases, and the restlessness which may be very prominent is perhaps the outcome of the somatic discomfort. Probably various paræsthesias give rise to the delusions. The cases often deteriorate, though the deterioration is apt to be of the milder type above sketched. Some cases begin with a state of apprehension and fear, or self-accusation, and then drift into such conditions with somatic delusions. Moreover, other absurd delusions may be combined with delusions of a somatic nature, so that there seem to exist transitions from this group to all the other possible states which we have described.

The following case is typical: A woman (Case VIII.), fifty-two and one-third years old, complained occasionally, over a period of ten years, that her throat was stopped up. Two months before her final menstruation she began to look run down, complained of pains through her body, and lost weight. Then the idea developed that she had uterine trouble, mortification of the spine, that she could not swallow, that the rectum was broken off, the body in two pieces, that she was getting copper-colored, was dying by inches. The ideas shifted. Then she became restless. Under observation she was very restless, but showed neither fear nor apprehension, only complained of the ideas below given, and said she felt "so restless." She claimed she could not swallow, that her throat was stopped up, that nothing went to her stomach; and since she receives no nourishment and yet does not starve she will never die; even if the head were cut off she would continue to live. Besides the sensations in her throat she complained that she could not feel her hands, but developed no delusions from this. She refused food, had to be tube-fed. Her weight from the beginning was very low. She remained in this state for a year, then calmed down, gained weight, dropped the ideas, but soon resumed them. She became inactive with loss of energy and a narrowed mental horizon.

The ideas may of course take various forms in different cases, such as "the face is falling in"—"the whole body is shrinking"—"the blood is dried up"—the patient is "only three feet high"—"nothing but a lip."

After the descriptions above given, the *diagnosis* of all these cases need not at length be discussed here. The differential diagnosis from manic-depressive insanity is mentioned under the diagnosis of that group. From general paralysis, with which some pictures may be confounded, the physical signs should guide us chiefly; from senile dementia, the memory defect there observed, and the greater confusion.

The *prognosis* must always be somewhat doubtful, but recoveries are not infrequently seen, and even comparatively grave cases may surprise us, after a number of years, with a recovery. Marked shallowness of the emotional reactions, notable insufficiency in thinking, with a poor grasp of surroundings and a narrowing of the mental horizon when the active symptoms are passed, speak for a permanent damage.

The *treatment* of cases of melancholia has to meet various indications. It is necessary to remove all disturbing mental influences as much as possible. At the same time rest is necessary and is a most important indication. It is time that the popular idea of diversion which usually involves much effort for the patient should be thoroughly eradicated. Diversions may do good in some depressions of constitutional neurasthenia, but in all severer depressions, above all here, it is entirely out of place. Rest in bed is often necessary. With it sufficient feeding—best, small quantities given often—is important. Tube-feeding may become imperative. At the same time the stomach and bowels need attention. Enemata or mild laxatives are usually called for, and the former are preferable. Stomach washing may be necessary and useful, but should not be done without indication. At night massage and warm baths may have a quieting effect, or various modes of partial or whole wet packs. Hypnotics should be sparingly used. Among them alcohol, chloralimid, and trional are the most serviceable. The fear may be alleviated by codeine, gr. $\frac{1}{8}$ t.i.d., or still better by tincture of opium, which may be started at ♏ v. t.i.d. and quickly raised to ♏ xx. or xxx. t.i.d. if borne well, and then gradually diminished again. If not tolerated or if it does not influence the condition it should be discontinued at once. There is no doubt but that it often alleviates fear a great deal, and it is strongly to be recommended. Another indication is a constant watch over the patient, because the danger of suicide is very great, especially at night. Most patients are therefore best sent to a hospital.

August Hoch.

XIX. INSANITY, MANIC-DEPRESSIVE.—In one form or another the old conceptions of mania and melancholia have been attacked for many years; modifications of either form were described; and their fundamental difference, if not from a psychological, certainly from a nosological point of view, was doubted by some. The sudden change from the melancholic to the manic syndrome, when it occurred in the cases with frequent alternations, made a deep impression and led to the description of circular insanity. However, so much weight was laid upon the peculiarity in the course of the disease without adequate consideration of the symptoms that the conceptions of mania and melancholia in general were not influenced by the views concerning circular insanity until Kraepelin showed that there exist in circular insanity certian fundamental symptoms which are also found in certain other cases of depression and excitement, in which the special characteristics in course which circular insanity presented were totally absent. These symptoms were carefully studied and were recognized in various modifications; and Kraepelin showed that we find not only combinations of these symptoms which fit the traditional conceptions of mania and melancholia, but also combinations which had hitherto remained unexplained, and which were by him and Weygandt termed mixed phases. Moreover, it was shown, as had already been claimed by some French writers for circular insanity, that all these cases also agree in the fact that they show no especial tendency to deterioration. Hence Kraepelin has included these various clinical pictures under the term "manic-depressive insanity." The features, then, upon which this conception is chiefly based are the existence of certain symptoms in various combinations, the tendency to recurrence (most pronounced in the classical circular insanity), and the absence of deterioration. The same determining data enable us to exclude other forms of excitement and depression, the more important of which are the following: In the young there are depressions and excitements which show a well-marked tendency to deterioration irrespective of the frequency or intensity of the attacks; among these are Kahlbaum's hebephrenia and katatonia. Kraepelin has united these with other forms under the head of dementia præcox. Whatever opinion we may entertain about the justification of this group, it certainly can be shown that the cases which it includes differ from manic-depressive insanity not only in the outcome (tendency to deterioration), but also in the symptoms, although the differential diagnosis may in certain cases present difficulties. Again, there are melancholias which differ not only in their pre-eminent occurrence in advanced years and their exhibition of a tendency to deterioration, but in their fundamental symptoms as well.

We find, therefore, in this conception of manic-depressive insanity, as well as in the classification of Kraepelin in general, an attempt to group the cases from a larger clinical or general pathological viewpoint than has hitherto been done. It is not only the more or less superficial symptoms, or the etiology, or the course alone upon which the grouping is made, but a combination of all the available data. In this general viewpoint lies the advance which Kraepelin's teachings have brought us, and in which Kahlbaum was his precursor. The whole classification as it stands will undoubtedly experience many modifications; but the general point of view must be conceded to be a fruitful one.

The best defined of the different clinical groups is manic-depressive insanity; nevertheless we are not justi-

fied in speaking of even this as a disease entity, for obviously when we know so little about the etiology and the actual nature of a condition, it is well to be cautious. Yet we must admit that it is an excellent clinical group based on the principles above given.

In the following an attempt is made to sketch the more important pictures which belong in this class as the writer has observed them in the course of his clinical experience. It has been deemed best to do this as much as possible by means of descriptions of cases; partly because this mode would seem to be more instructive, and partly because it permits those who may doubt the value of the clinical group of manic-depressive insanity to learn of at least some of the material upon which the conceptions are based.

Before we describe the clinical pictures it may be well to give a short résumé of those mental changes which at this stage of our knowledge we may regard as fundamental; a set of symptoms which in certain combinations gives rise to the many different clinical pictures we meet in this group. Obviously a deeper psychological discussion is out of place here.

We may divide the symptoms into those referring to the ideational, to the psychomotor, and to the emotional spheres. Thus we have "flight of ideas" and difficulty in thinking; increased psychomotor excitability and psychomotor retardation; emotional exaltation and emotional depression.

Flight of ideas was originally used to designate that ideational disorder which manifests itself in the quick succession of ideas more or less loosely associated and produced by the patient with great volubility. The talkativeness is, however, not always associated with it; and, in its absence, when the disorder manifests itself merely by a certain irrelevancy in answers and a loose connection of ideas, the term "flight" may appear inappropriate; nevertheless it is best to retain it for the symptom in all its manifestations. The essential feature seems to be an inability on the part of the patient voluntarily to guide his train of thought according to a definite aim; consequently he is at the mercy, as it were, of the arising associations or of occurrences which happen to attract his attention. Such patients are often distracted by words or happenings about them, and their train of thought is thereby deflected. However, the nature of this important symptom of distractibility is not quite clear; nor has it been possible to determine, so far as I am aware, why it is much more prominent in some cases than in others. In the sequence of ideas of a flight we can therefore recognize certain well-known laws of association (though the association is generally superficial), and a deflection by external happenings. By difficulty in thinking is here meant a certain slowness in mental processes. The patient's stock of ideas is not so fully at his disposal as usual; mental application to even simple tasks is more difficult; and a certain dearth of ideas is therefore the result. This may of course be present in different degrees ranging from a slight insufficiency to an almost complete mental standstill. Increased psychomotor excitability manifests itself in a greater tendency to keep in motion, and may range from a slightly increased general activity with loquaciousness to a wild maniacal excitement. Psychomotor retardation, on the other hand, is a term used to designate a certain difficulty in initiating voluntary action, which may present all degrees from a slight disinclination to move to marked slowness in all voluntary acts or even a complete akinesis. The emotional depression manifests itself in sadness and ideas in harmony with it, or in fear; while the exaltation may show any degree from mild exhilaration to exuberant wantonness. There are other traits which will appear in the description of the cases. The above are the most significant ones.

These different traits may appear in various combinations, the most lucid of which are the manic syndrome, consisting of flight of ideas, psychomotor excitement, and emotional exaltation; and the depressive syndrome: difficulty in thinking, psychomotor retardation, and emotional depression.

But there also exist other combinations in which the symptoms of the two syndromes are mixed. The clearest of these combinations are: (1) the syndrome of emotional depression with motor excitement and flight of ideas; (2) exhilaration with slowness of thinking and psychomotor retardation; (3) exhilaration with psychomotor excitement and retardation in thinking. Farther on, we shall discuss the special features of these combinations

Depressed Forms.—The pure depressive forms present, as was stated, three chief features: a difficulty in thinking, a psychomotor retardation, and an emotional depression.

Among these traits the difficulty in thinking and the psychomotor retardation seem to be the more fundamental; an emotional depression seems not to be a necessary accompaniment, nor does its intensity show any parallelism with the intensity of the other changes. Moreover, the difficulty in thinking and the psychomotor retardation have evidently a deeper relation with each other, and seem to be the outcome of a general retardation of voluntary efforts. In the mildest cases, therefore, we may have only a slight retardation of voluntary efforts which manifests itself in a feeling of inadequacy, and an inability to decide or accomplish anything for which a decided effort is required; while an emotional depression may be absent, or on the other hand be so pronounced as to hide the other alterations. In the more intense conditions, both thinking and moving are noticeably retarded, while the emotional depression is then almost always present to a greater or less degree. The various degrees of these changes are illustrated by the following cases:

Case I. is a druggist forty-two years old, who has had six well-defined attacks, all of them of the same nature as the present, while at one time he was for a week somewhat "keyed up." He woke up one morning with an "all-gone feeling," did not feel like going to work, and during the following day was "in a quandary what to do." He went to bed unable to work, and came to the hospital ten days later. The most striking feature about the patient was his inability to make up his mind to do anything, and his feeling of inadequacy. He described it thus: "I can't get hold of myself; I feel that something is gone, like my will, which enables me to concentrate my attention on what I am doing." "I have no energy." "When my condition is quite bad I simply have to give up, even if I knew the most appalling results would follow." He also said that when a question of judgment was involved he wavered more and could do a thing much less easily than "when it came naturally." Consequently when asked to do certain things, such as going in town to select some clothes, or occupying himself with wood-carving, he said it was perfectly impossible for him to do it, and every effort seemed to take on large proportions; while if he drifted into doing something such as playing a game or talking with those about him, or reading a paper, he did it without trouble, although in regard to the latter he often said that he had some difficulty in applying his mind. He was therefore occupied a fair part of the time, but he also sat or lay about, or walked restlessly up and down; the latter not in a depressed manner, but as it seemed because he chafed under the restraint which the condition of his nervous system imposed upon him. He complained much about his state, his digestion, the food, etc., but he did not make the impression of a melancholy patient, and never appeared gloomy. He never showed the slightest sign of slowness of motion, nor any disinclination to move, and at no time appreciable slowness in thinking. He felt only a great incapacity, and this he could not overcome.

This case presented, then, essentially the mildest degree of a retardation of voluntary efforts which showed itself in a feeling of inadequacy without a pronounced depression of feelings. These cases are not uncommon, though they are undoubtedly often called neurasthenia or hypochondriasis.

Another patient (Case II.) who had two previous at-

tacks gave much more the impression of "melancholia." He was often seen walking up and down saying, "O God, what will become of my family," and the like. He could see "no ray of hope"; thought he had been selfish all his life; told the physicians constantly that there was no use in doing anything for him. He was consistently depressed and gloomy. At the same time his feeling of inadequacy showed itself in utterances like "I cannot rouse myself to do anything"—"I have no individuality left"—"I cannot decide the simplest thing"—"I have not gumption enough to do the simplest thing." In this case it could be demonstrated that it was more difficult for him to apply his mind than normally, as it always took him decidedly longer to subtract continuously 7 from 100 down to 2 than it would naturally take a man of his education (he was a lawyer). A woman who was in a similar condition and who had been known for her brilliancy in conversation, expressed the greater slowness of her thinking by complaining she "had nothing to say" in conversation.

The emotional depression may be even more marked and may dominate the picture entirely. The pronounced self-accusation, with the familiar ideas of grave sins or crimes committed, having lost the soul, etc., or even more pronounced delusions, may exist. We also find that these patients sometimes complain of having lost all their natural feeling for others, which gives rise to renewed self-accusation. In some instances of this kind restlessness, which was indicated in Case II., becomes a pronounced feature. This, of course, may also obscure the other traits. Such cases may then resemble the melancholias of advanced years, although it seems that fear, which is in them common, is much less often met with in milder cases of manic-depressive insanity. Sometimes the picture in these milder cases may be somewhat obscured by the addition of imperative conceptions, either in the form of the insistent recurrence of certain thoughts, *e.g.*, of a sexual nature, or in the form of phobias or even the compulsion to repeat certain absurd acts. I have repeatedly seen such combinations in cases in which the diagnosis of manic-depressive insanity could not be questioned.

In more pronounced states the difficulty in thinking and the slowness in motion become more evident, as may be illustrated by Case III. The patient, an educated woman of fifty-seven, had an attack of depression when twenty-five years old. The present attack, which came on after some cause for worry, presented the following picture: In the first few days she was quiet, spoke little, worried, her motions were rather slow. This general retardation increased, she became slower in everything, and her answers, though spoken with fair rapidity, were slow in coming. She was slow in eating and dressing. Thinking was difficult; *e.g.*, it appeared a task for her to tell the year of the former attack; she gave her year of birth as '34 instead of '44; the continuous subtraction of 7 from 100 she soon gave up as impossible, etc. She looked depressed, and said she was troubled about her condition; soon her appetite became poor, and she complained of an obstruction in her throat, and feared her legs would get paralyzed. Then gradually a restlessness developed, at first very deliberate but in a few days more pronounced; while at the same time she developed fear, thought she was going to be dissected, had to go through a terrible ordeal, etc. At this time all her motions were faster, her sentences were longer, her speech was more prompt. After this episode, which lasted a few days, the former state again developed and the fear diminished. This case illustrates a moderate degree of retardation, and also that fear may to a certain extent overcome this retardation. This is important to remember.

A still more marked picture was seen in a young man of twenty-four who had had two mild depressions before (Case IV.). He sat about, moving very little, spoke seldom, every movement was extremely slow, and he had to be helped in dressing and eating. In order to give an idea of his slowness it may be stated that it took him thirteen seconds to count from one to twenty, though urged to do it as fast as he could. On another occasion when he was told to stand up, it took him twenty-five seconds before he started, then ten to go through the process. He wrote very slowly and with low pressure. It took him over a minute to repeat the alphabet. Simple calculations were done slowly and poorly (thus $100-7=94$, took twenty-five seconds; $9\times 8=72$, six seconds). At the first examinations he was not clear as to his whereabouts, nor was he clear about the month. He was able to tell when he had given up his work; but in other ways had difficulty in remembering. At times he drew away from those who came near him, evidently in fear, and once tried to escape through a window, on which occasion he moved quicker than at any other time. Besides this fear, which was often present, he always looked depressed, and said he worried much about his condition. He never showed any cataleptic symptoms nor was his drawing away anything like the negativism which is seen in catatonic patients (see Diagnosis).

It seems that patients who present these more marked degrees of slowness, though it takes them some time before they become oriented, have, after a time (if in the same place), a fairly good grasp on their surroundings; but they are inaccurate in estimating, for example, the elapsed time since entrance or since the previous visit. With increasing retardation, however, the patients become more confused. In these states also the retardation is quite consistent, and is noticeable not only in such acts as speaking and writing, but in walking, eating, dressing, and the like, in contradistinction to what we find in certain conditions of dementia præcox. The emotional state in these graver conditions is sometimes, as above, one of depression with episodic fear, self-accusation, and various depressive (occasionally quite absurd) delusions. Sometimes various delusions of persecution are noted. Sometimes a low moaning may be the only utterance of such patients, until we finally, after persistent questioning, obtain a whispered reply which evidently costs the patient considerable effort. These are not the most profound states, since an almost complete akinesis with probably almost complete mental standstill represents the most extreme picture. These are then the different depressive states. We shall later see that they may be modified by the admixture of manic traits, which considerably complicates the clearness of the pictures.

The Manic Forms.—The manic forms are characterized, as was stated, by psychomotor excitability, flight of ideas, and exhilaration. These traits are illustrated by the following cases.

The mild forms are represented by the case of a man forty-four years old—Case V.—who had had at the ages of thirty-one, thirty-seven, and forty-three, short mild attacks like the present, the second being followed by a mild depression in which he was somewhat dull.

The condition began a few weeks before admission and seems not to have been different from the state observed when in the hospital. He was constantly occupied, walking about as if he had urgent business, spending much time for example in clearing the garden of small pieces of wood or paper which he collected in a heap, and talking a good deal. His sleep was not interfered with; his physical condition was good. He showed no confusion in his understanding of things about him. He was amiable, exhibited a certain good-natured jolliness, and told stories, sometimes of a questionable character. Although his talk was often quite clear and his answers were to the point, he had a marked tendency to go into side-tracks and his talk was often peculiarly inconsequential. Thus, when asked why he had come to this hospital, he said, "I think if you were living at City Point and several mines went off, and some boats were wrecked, and then there was that explosion at the corner of Boylston and Tremont Streets, and don't you remember the fall of the Pemberton Mills at Lawrence?" When brought back to the subject he said, "What is the use of racking one's brain over old things?" Then he went on to speak of the history of the United States, the Fenian Raid of Montreal, the mode of living of the working men there

and here, of the social problem, continuing: "Everybody has a right to his own opinion; look at John B. Goff, look at Grant, look at Lincoln, don't you suppose that by forming these combinations and trusts something will happen? Talk about your foreign missions, why don't you attend to home missions first? Here are our sailors getting $16 a month and found, the cowboys getting $40 a month and found. Who wouldn't be a cowboy! It is the old question of capital and labor. There are the Swedes and the Danes, talk about dipsomaniacs and government by injunction, remember the Johnstown flood, they were all drinking in bar-rooms." We can trace the connection in this talk, but the whole is inconsequential and not governed by any central idea.

There are milder cases in which the flight of ideas is much less marked, and in which a certain exhilaration and over-activity are the dominant features. In many cases the alterations in character are very prominent. The finer feelings are in abeyance and, as Wernicke has put it, the emotional values of different ideas are levelled down. Hence tact, regard for others, delicacy, etc., are absent, the patients become coarser, and these traits, together with the fact that sexual feelings are often increased, are apt to lead to sexual excesses in men, to lack of modesty in women. Frequently alcoholic excesses occur. One man who was less flighty than the case just cited became the defendant in a number of libel suits, and also surprised his wife by suing for a divorce. In another similar case the patient had annoyed various authorities by his schemes to get rid of what he called various public nuisances. The expansiveness of such patients may become very marked even when the excitement and the flight of ideas are slight; they may speak of their wealth or of their personal superiority in a manner which suggests the initial stage of general paralysis, but in contradistinction to the latter their boasts are within certain possible bounds. The veracity of such patients may be very questionable, especially when their superiority or the wrong which they have suffered is concerned. Various traits of this kind may give to the picture a paranoiac color which may lead one who does not sufficiently consider the other alternations, and who is in general unfamiliar with the possibilities of these conditions, to a wrong diagnosis of some purely delusional state.

The emotional state in all these mild cases is either one of jovial exhilaration, of expansiveness, or episodically of irritability.

The cases thus far described have sometimes been designated as subacute mania, mania mitis, or hypomania. All possible transitions exist from these to the more active excitements, which represent the typical mania of most writers. The following case may illustrate this: The patient (Case VI.), a woman of thirty, who had had two former attacks similar to the present, was taken ill a short time before entrance. She spent her time tearing the bedding or rags which were given her for the purpose. With the pieces she draped herself in a fantastic manner; or she pounded the walls, sang, shouted, danced, and talked a good deal. In her talk she shifted from subject to subject, often did not finish her sentences, and the connection in her talk was at times impossible to trace; usually it was clear enough, though superficial, and sometimes sound associations were evidently the connecting link. Her talk was often deflected by utterances or acts of those about her; usually her volubility could not be broken into, and she answered but few questions directly. When the physicians entered, she at once accosted them, often abusing them for her detention or the next moment kneeling before them. Her mood changed often from an exuberant exhilaration to weeping, or scolding anger. She had her bearings and never mistook the identity of persons. She recovered after a few months.

In still more pronounced states the motor excitement may be more marked, but more often it is the flight of ideas which presents a greater intensity; the talk becomes more incoherent, and is either more dominated by mere sound associations (this seems to be the case when the motor excitement is especially prominent), or oftener the connection becomes more difficult to trace; then the confusion is greater.

This may be illustrated by the following case (Case VII.). The patient is a man forty-four years old, who had had a former attack of excitement from which he recovered. Under observation (the attack came on a short time before entrance) his condition was very stable. The most prominent feature was his constant talk, which will be presently described. Very often he lay in bed and would keep up an incessant flow of talk; again he would jump out, attack those about him, tear his bedding, shout. When up he usually did not keep on any clothes. His incessant talk continued when he was alone; when any one entered he at once directed it toward him, and usually ended by attacking that person. Generally expansive and exhilarated, this mood would quickly change to crying or more often to anger. It may be said that the motor excitement, with the exception of the talk, was less pronounced, certainly less constant and multiform, than that of the previous patient. His talk was flighty, even incoherent, so that it was usually difficult to trace the connection, but one could vaguely see through it, and recognize the loose association. Some of his utterances for which no connection could be found in his own talk, were evidently due to his attention being deflected by occurrences or objects about him. On looking over many samples of his talk it is noticed that it compasses comparatively few subjects, a feature which cannot be so well brought out in our limited citations as can the other features illustrated by the following, uttered in quick, commanding tones: " . . . Shut up or I'll kill you a year from to-day. You are my army mule, signed Gen. G. Custer, Jefferson Barracks. Leave it in Boston at the Adams House, suite 1. Take him out in the street and feed him on fish for life. As an honored man I got left. Give me soup. All I have had to-day is insult. . . . Bring me a piece of paper and let me sign my name the Czar of Russia. I am not Secretary Fish. I am XX; God only knows how dry I am. I want a fishing expedition from here to hell." Or: "Please express in person to your only sister; I love her. Rotterdam or any other damn place, I don't care. I am your American cousin, Abraham Lincoln, Jr. Judge F— I am your dead brother-in-law. He is not mad; he is at my apartments at the Astor House. What is your age? Mine is sweet sixteen. Go to hell. I am the Emperor of Germany. March General Lee to Washington, for I am the only sword I know. Who was the last Conqueror of the Rebellion? None of your damn business," etc. His confusion was marked and he evidently had a poor grasp on his surroundings. Often he did not seem to know where he was or was even unable to tell the month; he called only one or two by correct name, and these not always; the others were called by fictitious names and he never seemed to penetrate to a clear understanding of any one. We see therefore that this case differed from the former chiefly in the fact that, although the motor excitement was less marked, the talk was less connected, and the confusion much greater. There are of course cases in which this is even more pronounced. Kraepelin has described a delirious state which may occur in these cases—a condition with much clouding of consciousness, motor excitement, flight of ideas and numerous hallucinations. It may here be added that hallucinations, though not common, may occur in manic states even in considerable number.

The confusion above mentioned is always associated with the manic state if the flight of ideas is marked, and seems to some extent proportionate to it; while in other instances, when flight of ideas is slighter, a striking mental clearness may exist in spite of a very pronounced motor excitement. This confusion is characterized by the fact that the data of the surroundings are imperfectly elaborated, persons are taken for old acquaintances, the hospital ward for another building, and the like; at least this is the case when the patient is brought into new surroundings during the excitement, while it may be slight

in regard to persons or places he knows. It can often be demonstrated by questions later that a similarity in appearance or in the name, or some other superficial association leads to the wrong conclusion. Thus, one man who had persistently claimed he was in Windsor Castle, stated afterward that the heavy woodwork of the ward reminded him of that he had seen there, that the reason he called one of the physicians Lord Aberdeen was because he had seen the latter in Toronto, and the physician had told him he came from there. Such ideas may lead to other delusions. Thus, one patient was reminded by the grounds of the hospital of a place in Virginia where a relative lived; he concluded that one of the hospital buildings belonged to the relative, that the friends of the latter had built up their houses about him, and that two hundred years had passed by. Many other examples might be cited. These few may suffice. They show how the data of the surroundings, persons, places, and actions of those about the patient may be misinterpreted, and give rise to delusions. These are at times fleeting, especially if the excitement is great. In those who are quieter and yet have a considerable flight of ideas they may be held very tenaciously. The patients often not only utter these statements, but actually believe in them; and much that is incomprehensible in their talk and actions is thus explained.

If this difficulty in elaborating impressions, as we may call it, is associated with marked excitement and great flight of ideas, it impresses us as being the natural outcome of the general disturbance and certainly does not dominate the clinical picture. There are, however, cases in which this relation between the general excitement on the one hand, and confusion on the other is not preserved; cases in which the motor excitement and the exhilaration play a small rôle, but in which there is nevertheless a marked flight of ideas. As these patients are not, however, especially loquacious, this scarcely shows itself in a flight of ideas in the original sense of the term, but in a peculiarly confused talk in which we nevertheless recognize the same traits as in the flight of ideas. It is the confusion which strikes us most forcibly in these patients on superficial observation, while on more thorough study the more fundamental traits are as clear as in the other instances. These cases do not seem frequent in their most pronounced forms, but there are of course transitions from them to the more characteristic manic forms as well as to the so-called mixed phases which we shall take up later. Such a condition was seen for example in a young man of twenty (Case VIII.) who came to the hospital in his first attack. He began with a typical manic phase such as has been described above; then for eight or nine weeks presented a condition such as we are considering. It is interesting to note that after his discharge he was decidedly subdued for a time, and following this became slightly but decidedly exhilarated, both of which states must be interpreted as mild attacks.

This patient whenever seen was not at all excited nor loquacious; when he spoke it was in a natural tone, but he halted, broke off his sentences, looked puzzled, and what he said was usually very vague and confused. This was not the case when the subject was supplied to him, *e.g.*, when told to calculate or relate some definite occurrence which had taken place before he fell ill. Thus, to give one example: He was asked why he had written certain letters, to which he answered: "To pass away the time; I have been doing a lot of things that are decidedly foolish, writing these letters (pause); you see I have known Dr. H. here. I thought the work was divided up, surgical, medical, and of course the brain is a study by itself. Well, I don't know just how to say (pause); well, I tried to get a college education without going to college (pause); now speaking medically what I mean that I—well a—well—a—I want to purchase some stuff and I don't know how much has been used and how much has not been used." Asked to explain he said, "Well, I drew a plan here (pointing to a paper lying on the table) to show when I commenced smoking cigarettes, that affected my body—well, about cigarettes the law went into effect," etc.; or once he stated irrelevantly, "If Mr. X. would come and ask me about Odd Fellows what kind of a chart would you make for me?" (He had at that moment seen the physician take up a clinical chart.) The shifting of the subjects is very evident but the connection is often lost to the observer. In the last example especially, the external distractibility is evident (as was the case in many interviews); and the whole is clearly the same disorder seen in the earlier cases and shown by the same patient in a preceding phase. The puzzled look of the patient and his vague talk agreed well with his own interesting statement: "I start to say something and I don't know what I am saying, I am muddled—*one thing leads to another.*" The patient's confusion was also shown in the fact that, *e.g.*, he was scarcely ever able to tell when the previous interview took place, or relate the circumstances of it; he was never clear about the identity of certain persons, was not always sure where he was, and was moreover never able to give the gist of a pararaph given him to be read (a very good test for patients with flight of ideas). But he calculated well, and showed a good memory. He was never excited or talkative while in this state; he often walked aimlessly about, or lay around, talked in the manner above indicated, and wrote a considerable number of flighty letters. Exhilaration showed itself only on rare occasions.

It remains for us to illustrate certain possible combinations of symptoms, of which we have above spoken as mixed phases. It should be understood that there are all possible transitions from the simple manic or depressed states to these "mixed" conditions, and that as short episodic states they are by no means uncommon, especially in manias.

The following instances represent some typical examples of the mixed states: The patient, a woman of thirty-four (Case IX.), had had two previous attacks, the first of which seemed from her own description a characteristic mild attack of depression such as that illustrated by Case I. In the second attack, which lasted longer, she was depressed, complained of many pains, and according to the physician's statement was considerably agitated, talked rapidly, was opinionated, morbidly religious, and when somewhat excited was distinctly erotic in her conversation. In November, 1898, she began to get depressed, with pronounced self-accusation and inability to attend to her duties; again, she was active, walked about much, slammed doors, and talked considerably about her troubles.

Under observation she complained much of being condemned, of having lost her peace with God, etc., and appeared very depressed. When she was examined it became at once apparent that she was very loquacious, and though some questions were answered directly it was found that sometimes she had to be asked again and again but would invariably wander from the subject without returning to it. Her talk was, however, all in a depressive strain. After a few weeks' stay at the hospital the depression left her and she was slightly exhilarated, though not flighty. This patient, then, represents a case of depression with loquaciousness and distinct evidence of flight of ideas. Probably the former attack also represented a mixed phase. But not all depressions in which the patients become more talkative need be regarded as due to the admixture of manic traits, as the talkativeness may also have emotional causes, in which event it is associated with restlessness, as we have above pointed out (Case III.). The flight of ideas is then of course totally absent.

A different combination, and one which would naturally present more difficulty for diagnosis, is shown by the following case (Case X.): The patient is a young woman of twenty-four, who with the exception of a slight, short nervous breakdown, in which she is said to have become tired easily, has been well mentally till the present attack. After working very hard she became very tired, had some vomiting spells, and was in bed for two weeks. Some time later she became excitable and

peremptory. Soon she began to complain of being unable to think and became rapidly confused. Her condition then was the same as that seen while she was under observation. It was very stable. She usually sat or lay in bed, and never showed much tendency to move about; her toilet had to be attended to by the nurses, and she had to be fed by them. At times she was untidy. A large part of the time she muttered to herself more or less distinctly, or hummed—all this in a rather deliberate manner. Her face usually wore a bright smile which gave her a rather alert expression and contrasted strikingly with the difficulty in thinking which she presented. Often enough she laughed out, never loudly. Sometimes she looked dull, again rather puzzled. It was sometimes rather difficult to attract her attention and she never showed any distractibility. She was usually unable to solve any but the simplest multiplications or additions, could not tell the number of weeks in a year, the plays of Shakespeare (she studied elocution), the names of more than one of her teachers, her school books, and the like. She knew no names of those about her, except that once or twice she recalled a name she had often heard. Sometimes she knew she was in a hospital, again said she was at home, or simply she did not know. She could never tell, except in the very beginning, how long she had been in the hospital, nor could she give the day, month, or even the season. Some of her utterances as "my memory is wretched," "Oh dear, I can't think," and the like also showed her difficulty. Sometimes when test questions were asked she said with a happy, broad smile, "I don't know."

Her talk, which also shows peculiar fantastic ideas, was like what follows: "Why, I don't—I don't know anything about—no—well—I tell you—well it is too bad," etc., this being often repeated with a peculiar wondering inflection, or: "Look, look, what have I done!—Yes, why —he found a cloud then eternity—we had a lovely time (making motions with her hand as if playing the piano). I am way up in eternity—who is the doctor—no it's the sun. I am the Queen of Eternity," etc. Or, looking out of the window, she said: "You dear little birdie, you dear little birdies and chickens, don't you see that little bird? . . . I feel as though I was all colors of the rainbow"; or, "I am the sun and you are the moon and you revolve around me, this way and that way; no, this is the heaven and I am the moon," etc. All this was often said with a broad smile and at times was sung softly. The same smile was present when she uttered depressive ideas, such as "I want to die." "Is my soul lost?" "Have I to lie down with silver and gold?" Only at times did she moan. This state, which lasted for some months, was very imperfectly recalled afterward. After a clear period she showed a typical picture of a manic excitement with great exhilaration, flight of ideas, and distractibility. This case, therefore, presented fundamentally a profound difficulty of thinking, but with it an exhilaration and a tendency to much talk. The typical flight of ideas and distractibility were absent, and the slowness in motion, which a simple depression with such marked difficulty in thinking would present, was so modified that though she talked much, it was done very deliberately and in general she showed little tendency to move. The most marked features are therefore those of a depressive phase modified by the manic features of exhilaration and loquaciousness.

Finally, we may cite the following case (Case XI.): The patient, a man of thirty, came to the hospital in a typical attack of manic excitement, such as above described, which lasted for six weeks. Then followed a period in which his motor excitement and exhilaration continued, but he spoke very little or made silly, weak remarks, whistled the same tune over and over, made comical faces, pointed at those about him and laughed, was very mischievous. Gradually the motor excitement subsided somewhat, he sat about a good deal, but continued to be mischievous at times, and to laugh much. He showed great difficulty in thinking, was slow in calculation and in giving answers which required thinking, and had a poor grasp on the surroundings. This patient presented more of manic features as expressed in the whistling, grimacing, the motor excitement, the mischievousness, and the exhilaration; while his depressive traits were evident in the difficulty in thinking, in the weakness of his remarks, and in his actions. The impression which the patient made was one of silliness and certainly would have suggested dementia were it not for an analysis of the traits which made the correct diagnosis possible. He recovered completely.

We should finally mention some cases in which neither the manic nor the depressive element is very prominent, but in which, more or less episodically, excitements occur with angry scolding and some flight of ideas, while in the interval a certain difficulty in thinking exists, with perhaps a general disinclination to move, overshadowed, however, by the existence of delusions. These delusions are held rather tenaciously and may be combined with hallucinations, which are not infrequent in all mixed phases.

These cases may suffice. It would lead us too far to illustrate other modifications. One thing should perhaps still be emphasized, namely, that various combinations may occur during one attack, so that at one time one picture, and, a few days later perhaps, another picture is seen.

In closing this description of the clinical manifestations of manic-depressive insanity, we should not omit to state that it may at times, especially in certain mixed phases, be difficult to recognize the fundamental traits. For the study of such conditions cases which have had typical attacks, especially those in which a typical attack preceded or followed the more obscure picture, are very important. For it would certainly appear forced to regard the obscure picture as due to a totally different disease. It was for this reason that the three cases (VIII., X., and XI.) were especially selected as illustrations. But we must warn distinctly against the impression that such cases are necessarily preceded or followed by a manic attack.

It should also be added that we are still far from a full understanding of the symptoms and the laws which govern the symptoms of manic-depressive insanity.

The bodily condition suffers in almost all the severer cases, while in mild manias it may distinctly improve and the whole appearance of the patient may become more flourishing and his body weight rise. Usually the weight falls—in some excitements in spite of much food being taken. The sleep is almost always interfered with. The appetite in depressions is usually, in excitements sometimes, interfered with. In depressions the bowels are sluggish. The temperature may be subfebrile in excitements.

In regard to the etiology of manic-depressive insanity we must mention that heredity plays a striking rôle, and in the family history we often find mention of recurrent attacks of insanity not followed by deterioration, from which fact a direct heredity seems by no means infrequent. The individual attacks often occur without any appreciable cause; sometimes exhausting influences, acute diseases or puerperium, or some emotional strain seems to precipitate the attack. The same may perhaps be said of alcoholic excesses. In one instance I have seen a traumatism of the head, and in another a cerebral embolism, clearly produce a typical attack.

The nature of the disease is entirely obscure and it would seem superfluous to produce hypotheses when we know so little. The pathological anatomical findings are practically nil.

No definite principles can be given about the general course of the disease. Some patients present very many attacks, others few. The typical circular insanity with the depression, excitement, and free interval followed by the same cycle, is comparatively rare. More common are a recurrent depression and recurrent excitement; but frequently we find that an attack of excitement may replace one or more attacks of depression, and, vice versâ, that a mild exhilaration may follow one of the depressions, or

that a so-called "reactive" melancholia may succeed an excitement. Mixed phases may occur in cases which have before presented only pure depressions and excitements; or, again, all the attacks may be mixed phases. Most cases have repeated attacks, though the intervals may extend over many years (see Case III., *e.g.*). It is also important to note that a number of mild attacks may suddenly be followed by a very grave one, while a case with a series of grave attacks may in the interval show mild short attacks. The duration of the individual attacks varies from a few weeks to a number of years: half a year is perhaps a fair average. The first attacks occur usually in early life but may occur later; and sometimes even a classical circular insanity may commence at or after the menopause. The attacks may show a striking periodicity; much more often this is not the case. I have twice seen regular daily alternations persisting for a number of months. It may here be added that cases of manic-depressive insanity are very common.

As was stated, the cases of manic-depressive insanity show no essential tendency to dementia. But after many attacks, and in rare instances after a few attacks, a certain more or less pronounced mental deterioration may nevertheless develop. Such patients become irritable, morose, show poor judgment and lack of application, and therefore are unable to earn their living, and may have difficulty in living outside of an institution. Kraepelin states that in cases with very short intervals the deterioration may be much more profound.

Diagnosis.—Only the main points in diagnosis can here be taken up, but it is hoped that together with the descriptions above given they may form a guide to a correct diagnosis in the bulk of the cases. It seems best to discuss separately the diagnosis of the depressions, the excitements, and the mixed phases. But a few remarks should first be made about former attacks.

One or more previous attacks followed by recovery, especially when both excitement and depression have occurred, may be a considerable aid in diagnosis. The greater the number of attacks the greater the probability of manic-depressive insanity. But cases of dementia præcox may present one or more attacks with recovery, as may general paralysis even, although in both these conditions, especially the latter, some signs of deterioration are more common. Hysteria and epilepsy also show a tendency to recurrence. In a depression at the involution period it may be of considerable assistance to know that the patient has had one or more depressions or exhilarations in youth, as this speaks very strongly for a manic-depressive nature of the depression.

The most important means for a diagnosis, however, is a careful study of the symptoms.

We may, as in the clinical description, divide the depressions into: 1. The cases with slight retardation showing itself mainly in a certain incapacity and feeling of inadequacy. These cases chiefly resemble neurasthenia, and are especially important to the general practitioner because of the differential diagnosis. For manic-depressive insanity speak the absence of a cause, an abrupt onset, an actual incapacity and feeling of inadequacy instead of the great proneness to fatigue, the existence of former similar attacks, or similar attacks alternating with phases of "nervousness" or slight exhilaration, not to speak of graver attacks. The early "neurasthenic" states of general paralysis rarely present any difficulty in differential diagnosis, but for this the reader may be referred to the section which treats of general paralysis.

2. The cases in which the emotional depression is added to the above slight retardation, which may then be hidden. Here the various melancholias which are mentioned in the section devoted to that topic must be excluded. A well-marked feeling of inadequacy may here show us the way, but it should be stated that it may be difficult to recognize the manic-depressive nature of such cases unless we have former attacks to guide us, particularly with excitement or well-marked retardation. There are especially two kinds of melancholias which have to be differentiated from the cases under consideration: the involution melancholias and certain conditions of dementia præcox. Besides the age, and the absence of former attacks, it is pre-eminently active fear on the one hand, and on the other a certain shallowness of emotional reaction and the existence of absurd delusions which speak for involution melancholia. From the cases with retardation of motion, the involution melancholias are differentiated without difficulty. In dementia præcox depressions occur without retardation. In these the depressive ideas are apt to be absurd, the thinking is somewhat scattered, and the emotional reaction may be singularly shallow,—a certain emotional indifference. On the other hand, in the cases of manic-depressive insanity this indifference is never present.

3. The hypokinetic states. By this term we mean the states in which the retardation shows itself in a slowness in thinking and (as the name indicates) in motion. For these cases we may lay down the general rule that unless manic traits or fear modify the picture the retardation of motion and the difficulty in thinking show a certain correspondence in degree. Moreover, the slowness in motion is consistent and shows itself in all voluntary acts. Therefore a pronounced inability to think, not associated with a corresponding slowness in motion, speaks, in the absence of manic traits (exhilaration), against manic-depressive insanity. Such conditions presenting other features in addition are seen in general paralysis.

Again, states of well-marked mental weakness without corresponding psychomotor retardation (though there is disinclination to move) occur after acute diseases such as typhoid fever, measles, diphtheria, etc. It should also be recalled that there are various grades of stupor which occur in grave brain diseases (meningitis, etc.); in these, again, the "tied-up" state (as a patient called it) is absent.

A retardation may also be simulated by an apathy (cases of dementia præcox may develop this state without active symptoms). Here the general disinclination to move is not associated with slowness of motion, and calculation tests give almost normal results, yet the grasp on the surroundings may be rather poor. In cases of mutism, with or without other akinetic phenomena, we can exclude manic-depressive insanity, if the motions in general are not correspondingly slow, or if we can ascertain (by facial expression) that there is no corresponding slowness of thinking. Such cases of mutism occur in dementia præcox. The various hypokinetic states belonging in the group of dementia præcox are the most important as well as the most difficult to differentiate from those of manic-depressive insanity. Hence it is in order to mention here certain features which are especially characteristic of the former. These are (1) cataleptic phenomena, by which is meant the tendency of a limb, when passively placed in any position, to remain in that position for an unusually long time. This is also shown in the spontaneous assumption of odd positions which may be retained for varying periods of time. (2) The negativistic phenomena. The clearest negativism exists when every passive motion, no matter in which direction it is exerted, is at once met by marked resistance. Thus, for example, if we press the head of the patient backward it is at once strongly pushed against our hand, so that it springs forward the moment the pressure is relieved; or, if in the next manipulation the pressure is exerted in the very opposite direction, the same phenomenon is again seen. This symptom may be general, that is, may show itself at any place where we touch the patient, or may be confined to special muscle groups, such as the neck and lower jaw for instance. It is not necessarily consistent. Negativism may also show itself in other ways. These symptoms are foreign to manic-depressive insanity. Hence, if we have to diagnosticate a hypokinetic state, catalepsy, the assumption and retention of odd positions, together with signs of negativism speak, besides the traits above mentioned, against manic-depressive insanity and for dementia præcox (katatonia in the stricter sense). Negativism must

not be confounded with warding off movements and resistance due to fear. There are, of course, other features which might be cited as differential points—we will add only the sudden disappearance of the hypokinetic symptoms for short periods, during which the patient may be very clear. Such intermissions are less apt to occur in manic-depressive insanity, except in mixed phases, in which cases the patient shows manic traits in the interval.

The manic states may present more difficulty for diagnosis than the depressive states. Motor excitement is a more common symptom than psychomotor retardation, and is seen in the most heterogeneous states; it is probably produced in various ways. Again, flight of ideas may be difficult to recognize at its height, and occurs not only in manic-depressive insanity, but in other states as well—notably general paralysis, certain states of exhaustion, and in some forms of dementia præcox. Nevertheless a great many cases present no difficulty for diagnosis. The following general rules, while not claimed to be absolute, may be valuable as guides. The pure manic excitements present a motor excitement in which many of the motions are movements of expression; they are multiform and we can see a meaning in them. The talk, also, though it may be quite incoherent, is not totally incomprehensible and we can see a loose connection. Distractibility is very common. The confusion is proportionate to the intensity of the flight and shows itself in mistaking of persons and places. The patient presents a certain alertness. In the various excitements of "somatic" diseases these relations do not exist, and flight of ideas cannot be recognized. In the deliria the dulling of consciousness is much greater and hallucinations are more prominent than in manic excitement. The same may be said about the excitement of acute exhaustion.

In the excitements of epilepsy neither flight nor distractibility is present and the disorientation is very pronounced. Hysterical excitements are of short duration and also present no flight of ideas. It may be very difficult to differentiate the excitements of general paralysis from those of manic-depressive insanity. The prodromal state, the age, the history of syphilis, and the physical signs are the best guides. We have above spoken of the similarity which certain mild manic states may bear to general paralysis, and have shown that it is, besides the points just mentioned, especially the greater absurdity of the delusions which speaks for general paralysis.

The most important differentiation must be made from the excitements of dementia præcox. This differentiation is usually readily made, but may also present considerable difficulty. We may here, for practical purposes, divide the excitements of dementia præcox into the more typical katatonic excitements and into those which resemble more the so-called hebephrenic excitements. The latter are more difficult. The motor excitement and the talk may both resemble manic-depressive insanity, but they are apt to be less multiform; the talk, in spite of striking clearness in the patient's understanding of things about him, may be more confused, scattered and reiterative. These are points which can best be appreciated in a stenographic report of the talk. At the same time very absurd ideas may be associated with a comparatively mild excitement; such a condition may be especially striking in a remission. Instead of the frank exhilaration, we find a certain silliness; or, in other instances, an ecstatic mood with mystical, religious delusions; this latter mood, according to my experience, seems not to occur in manic-depressive insanity. Sudden non-periodic remissions with striking clearness, or episodes with akinetic katatonic traits, may also be valuable in the differential diagnosis.

The katatonic excitements may show a motor excitement, which differs clearly from the manic. While in the latter the movements are multiform, seem to have a meaning, and are often gestures, they are in the former more aimless, more impulsive, one might say coarser, and they make more the impression of something forced; often they are quite stereotyped. With such an excitement there may be no talk whatever, or it may be strikingly stereotyped, consisting in the repetition of words or sentences, or again remarkably confused in comparison to the clearness of understanding. The emotional state is here not one of exhilaration, but rather of indifference; at times silly, or again at intervals ecstatic, in which case a peculiar, forced, rather nonsensical talk with much pathos may be noted. Here the alternation with akinetic traits is more common than in the other states above mentioned. Flight of ideas and distractibility are absent in these cases.

In the diagnosis of mixed phases we must keep in mind the chief possibilities of combination—since it is the very combination of symptoms which is characteristic. Thus, in pictures which present melancholic traits, the existence of flight of ideas may be said to be diagnostic. The same symptom is also important in cases in which the delusional element is the most prominent. In states of mental insufficiency with a poor grasp on the surroundings, clear indication of an exhilaration (represented by frequent laughing and smiling, or certain mischievous actions) is characteristic and we shall usually find certain evidences of a modified motor retardation associated with it. These cases may be mistaken for certain hypokinetic states of dementia præcox; and we must guard against mistaking the peculiar set smile which is sometimes seen in akinetic states of dementia præcox, and which seems to express no emotional state, for the frank smile of the manic-depressive which denotes a happy mood. We must also clearly differentiate between impulsive acts which may occur in dementia præcox and certain mischievous acts of the cases under consideration.

Those states which are pre-eminently excitements may by their sterility in talk, and silliness in talk and actions, suggest excitements of dementia præcox; in such cases the evident disorder in thinking, manifesting itself in a difficulty in answering simple calculation tests and memory questions, as well as in the poor grasp on the surroundings, will help us to make a correct diagnosis. We see, therefore, as was stated, that it is here, as in all mixed phases, the peculiar combination of symptoms which points the way to a correct diagnosis.

It is practically of great importance that when once we feel sure about the diagnosis of manic-depressive insanity, we are justified in giving a good *prognosis* so far as recovery from the attack is concerned. This knowledge is especially important in the protracted attacks and certain mixed phases which give the impression of dementia; and while recurrences are always to be feared, recovery from each attack may with few exceptions be confidently expected. In regard to recurrences it has been my experience that if all the cases are taken into consideration, we find that the classical circular insanity as well as the frequently recurring manias and depressions are in the minority, and that cases with few attacks are more common. It is impossible, however, to say in a given case whether many or few attacks will follow, unless a tendency in the one or the other direction is already established by the previous course; even this consideration is not absolutely binding. On the whole the cases with good heredity, occurring subsequently to well-marked exhausting influences or the like, and after the age of thirty, are in this respect prognostically more favorable than early cases with bad heredity and without appreciable cause, especially if the first attack is short. In the climacterium recurrences are not uncommon.

The *treatment* of manic-depressive insanity is, of course, only a symptomatic one. States of excitement, with the exception of the mild ones, should always be sent to a hospital, unless a sufficient number of nurses can be procured. In the short time which elapses before this transfer can be effected, it will scarcely be possible to avoid the use of sedatives, which should otherwise be as much as possible dispensed with. Bromides in large doses, and hyoscine gr. $\frac{1}{200}$ to $\frac{1}{100}$, administered hypodermatically, have a quieting effect. The general treatment consists in the exclusion of all exciting influences. For this purpose bed treatment should as much as possible be employed;

with this should be combined prolonged baths (temperature 98° F.). The patients soon get used to this treatment, though sedatives may at first be necessary to make it feasible. The effect is often remarkable and the sleep is generally improved. For the attainment of the latter object trional, paraldehyde, chloralamid, or alcohol may also cautiously be administered. Sufficient feeding is very important, and tube-feeding may have to be resorted to. Stimulants or strychnine may be necessary. Cases of manic-depressive excitement should not end fatally from exhaustion if treated properly.

For the treatment of depressive states I refer the reader to what has been said in regard to treatment in the section devoted to *Melancholia*, and I will here only add that in the mild cases of depression the patients should not be prodded to exert themselves, nor should diversion be forced upon them, since the condition is only aggravated by these measures. On the contrary all responsibility, all exertion, should be taken away from them and a large part of their day should be spent in bed. The idea of the benefit of forcing exertion upon these people arises from a misconception of the disorder. Suicide is to be feared and guarded against in even the mildest cases.

August Hoch.

XX. INSANITY: MANIA.—Under the head of mania various states of excitement have been included; but as is the case in melancholia, which the writer has treated in another section, there is little doubt that heterogeneous clinical pictures have here been united. The most important form of excitement and that which seems to have been the basis for most descriptions of mania is the symptom complex which represents a part of manic-depressive insanity. Some may question whether all forms of mania presenting the features there described belong actually in this group, and whether there does exist a mania as such. Whatever position we may take in this matter we can affirm that it is not possible to separate symptomatically such a mania from the excitements of manic-depressive insanity. There is consequently no occasion here to describe these states, and the reader may be referred to the section devoted to manic-depressive insanity. Excitements also occur in various other diseases, some of which manifest themselves pre-eminently by mental symptoms, while there are others in which mental symptoms are only occasionally seen. Among the latter we may mention myxœdema and Graves' disease, and the delirious excitements of various acute infectious diseases. Mental diseases in which excitements occur are chiefly general paralysis, senile dementia, epilepsy, hysteria, dementia præcox, and the excitements following upon acute exhaustion. The symptomatic characteristics of these various forms will be found in the sections which specially deal with them. Under the diagnosis of manic-depressive insanity, the writer has attempted to indicate some of the features that characterize the excitements of dementia præcox.

A word may be said about chronic mania. There are cases which more or less persistently present states of excitement for years. Some of these are prolonged attacks of manic-depressive insanity, with ultimate recovery; a few are undoubtedly cases of manic-depressive insanity in which the intervals between attacks have become shorter and shorter until finally the attacks run together; some are cases of dementia præcox remaining permanently excited; but finally I must acknowledge that there are cases in which the condition is by no means clear.

August Hoch.

XXI. INSANITY, DEGENERATIVE.—The insanity of degeneracy comprises those forms of mental disease which seem to bear a close relation to defective hereditary endowment.

The term was first used by Morel (1860) in his etiological classification, where he applied the name to three types of cases in which faulty heredity was the most prominent factor. These groups were: the insanity resulting from congenital nervous temperament, moral insanity, characterized more by the disorder of the actions than of the intelligence, and the feeble-minded, the subjects of morbid impulses and those prone to commit criminal acts. From this time the insanity of degeneracy has been recognized as forming one of the larger groups of the insane. Following Morel, Schüle and more recently Krafft-Ebing, Dagonet, Regis, Magnan, Spitzka, and Berkley have maintained the same view. The different forms of mental diseases grouped here have, however, varied somewhat with the different writers. In general it may be said that the term has been used in a broader sense by German and American psychiatrists than by the French.

Krafft-Ebing laid stress upon acquired degeneracy, that arising from head injury, disease of the brain, and anomalies of development, and also characterized the insanity of degeneracy by certain general features which distinguished it from another large group of cases which seemed to arise quite independently of any faulty endowment, the functional psychoses or psycho-neuroses. In a general way these characteristics were: the insanity of degeneracy is constitutional, *i.e.*, it appears in individuals who from early childhood give evidence of a faulty constitution, and whose mental equilibrium is always easily disturbed; the exciting causes may be nothing more than the physiological phases of life (puberty, puerperium, climacterium, and menses); there is little tendency to recovery, but remissions and periodicity are notable features, and there is also a tendency to transmission of insanity to the progeny in an even more severe form. He groups here reasoning insanity (folie raisonnante), paranoia, periodical insanity, including dipsomania; neurasthenic insanity, including compulsive insanity; epileptic and hysterical insanities and hypochondriacal insanity.

Spitzka includes practically the same forms of mental disease in this large group. Macpherson places here premature dementia (hebephrenia), moral insanity, paranoia, folie-à-deux, aboulia, obsessions, impulses, perversions of instinct and conditions of arrested mental development.

Berkley places in this group paranoia, periodical insanity, epileptic, hysterical and neurasthenic insanities, and remarks that it probably includes more cases than any of the others, that the onset and prognosis are essentially different, and that the "one-sided or warped evolution of mental faculties is usually to be traced to anatomical abnormalities such as defective development or malformation of the cranial bones with imperfections in the brain structure, especially in convolutions, and abnormalities in the vascular construction."

Kraepelin fails to recognize any features characteristic of this large group except that of heredity. He says, introductory to the last half of his text-book, that following the involution psychoses, those forms of insanity are described in whose origin a defective basis becomes a more prominent factor. These psychoses are manic-depressive insanity, paranoia, the constitutional neuroses (epileptic and hysterical insanity and traumatic neuroses), the constitutional psychopathic states (compulsive and impulsive insanity and contrary sexual instincts), and the conditions of arrested mental development.

The French psychiatrists, including Magnan, Dagonet, and Regis, limit the insanity of degeneracy to a small class of cases, which includes only the imperative ideas, the impulses, contrary sexual instincts, moral insanity, and the conditions of arrested mental development.

While one can readily recognize the greater prevalence of defective heredity in the large group assigned to the insanity of degeneracy by Berkley, Krafft-Ebing, and others, it must be admitted that there is an absence of any characteristic phenomena either in symptomatology, or course, or outcome in common to all or most of the forms grouped here, excepting the constitutional psychopathic states and arrested mental development, which would warrant such a classification. In comparing manic-depressive insanity with paranoia, for instance, the mode of onset and the age at which it occurs, the individual symptoms, the course of the disease, and the ultimate outcome are essentially different in each. The advance-

ment in psychiatry during the past two decades, with the growing conception of definite clinical entities, each with its own characteristic symptomatology, course, and outcome, has rendered the gross separation of psychoses depending alone upon heredity, of secondary importance. Furthermore, there has always been a considerable number of cases allotted to different forms of the insanity of degeneracy, in which there were absolutely no evidences of faulty heredity, and in many of these the characteristic symptoms have appeared only after an injury, infectious diseases, or an emotional shock in infancy or youth; and there are still other etiological factors such as faulty training and masturbation, which seem in individual cases to be of equal import to faulty heredity. While it still may be said, with the exception perhaps of dementia præcox, that defective heredity is more prominent in paranoia, manic-depressive insanity, the constitutional neuroses, constitutional psychopathic states and arrested mental development, than in the other psychoses recognized by Krafft-Ebing as the functional or simple psychoses; there is, in fact, very little of similarity in the symptomatology to warrant their being grouped under one heading.

Manic-depressive insanity is characterized by a recurrence at varying intervals throughout life of mental disturbance of a maniacal or depressive character or both, unaccompanied by progressive mental deterioration, the patients, in the vast majority of cases, in the interval being able to return to their usual employments. Paranoia is characterized by the gradual morbid transformation of the entire psychic personality accompanied by the development of fixed delusions, which are maintained throughout life, becoming more and more systematized, but without impairment of the perceptive faculties, the memory, or coherence of thought.

The constitutional psychopathic states and arrested mental development are the only forms of the so-called insanity of degeneracy which present common characteristics beyond the mere prevalence of faulty heredity, which would possibly justify a common grouping and the application of the name of the insanity of degeneracy. These forms are characterized by stigmata of degeneracy in both the physical and mental fields.

In the mental field the stigmata vary from more or less complete arrest of development of the intellect and the moral sense to mere anomalies of these faculties. The arrest of development may be both intellectual and moral, producing imbecility and idiocy (arrested mental development) or may involve only one of these fields, as in the case of moral imbecility (moral insanity). However, whenever the moral defect is very pronounced, more or less intellectual enfeeblement accompanies it.

The mental impairment is usually general and involves all the more complicated mental processes; apprehension, memory, judgment, association of ideas, emotions, and volitions; but there is a class of patients in whom an impairment of some of the faculties is accompanied by an exaggerated activity of others, as of memory or the association of ideas with enfeeblement of the will or judgment. Some are regarded as intellectually bright, but commit the most absurd acts and show the credulity of a child, there are idiots who exhibit remarkable taste for drawing and music, and some imbeciles have an excellent memory for dates or calculate with great ease and accuracy.

The disharmony of the intellectual and the moral faculties is one of the most striking features of degeneracy. As in the defects of the intellectual development, so in the moral sphere, the condition varies from a complete arrest of moral development to all forms of moral perversion and even to an abnormal development of the moral and emotional sensibility. All of these conditions may exist with a perfect development of the intellectual faculties. The conditions of arrested moral development comprise moral imbecility. Among perversions are those of the sexual sense, which include bestiality and what Westphal calls the contrary sexual instincts. This last also includes masochism and sadism. The professional criminals should also, without doubt, be included in this class, as they present all possible varieties of moral perversions and anomalies, all of which may exist with preservation of the intellect and even with intellectual keenness. Finally there may be only an extreme mobility of the emotions, an extraordinary susceptibility to impressions of every sort. The extreme type of this condition constitutes congenital neurasthenia.

It is upon the basis of such mental stigmata that compulsive and impulsive insanity and contrary sexual instincts arise. Magnan terms these the episodal symptoms of the insanity of degeneracy. It is a general characteristic of these disturbances to appear very early in life and especially during puberty.

Physical stigmata, which exist from infancy, include anomalies in the development of the cranium, face, body, and limbs; asymmetries, malformations of the external ear, strabismus, faulty speech, including stuttering, thickness of the lower lip, malposition of the teeth, atypical palate, prominence of the lower jaw, hypospadias, epispadias, anorchism, etc., etc., all of which are more fully treated in the description of *Insanity from Arrest of Development: Imbecility and Idiocy.*

As arranged by the editor of the Handbook, the insanity of degeneracy, as described here, will comprise paranoia, and manic-depressive insanity, the description of which will be found elsewhere under those respective headings, circular insanity, the constitutional psychopathic states, including congenital neurasthenia, compulsive and impulsive insanity, and contrary sexual instincts; also moral insanity, folie-à-deux, and hypochondriacal insanity.

Circular Insanity (*Folie circulaire, Folie à Double Forme*).—The recognition of circular insanity as a distinct form of mental disease dates from Falret (1851) and Baillarger (1854). According to them it could be distinguished from ordinary mania and melancholia, and was characterized by regular periods of depression and elation, which succeeded each other with or without an intermission of lucidity, the duration of the attack varying from one or more days to a year. The transition might be sudden or gradual, the former being the case when the attacks were short. It was also recognized that the disease was markedly hereditary, appeared mostly in women, and had an unfavorable prognosis.

The mental phenomena characteristic of the disease were further elucidated by Meyer (1874), Mordret (1883), J. Falret (1890), and finally Ritti (1892). According to these writers circular insanity consists of recurrence of periods of mania and melancholia, which, when separated by longer or shorter intervals, constitutes the periodical type, or without the interruption, the circular type. The periods of mania are one of two types: simple mental exaltation, characterized by an over-excitation of all of the faculties, perceptive, intellectual, and volitional, without incoherency of speech, sometimes accompanied by impulsive actions, such as dipsomania, kleptomania, and nymphomania; or, pure mania with incoherency of speech, frequently clouding of consciousness, and sometimes with delusions of exaltation. The periods of melancholia are of three types: simple depression of the mental and physical energy, absence of will power, and an incapacity for action but without delusions; melancholia in which simple depression is complicated by depressive delusions, either of self-condemnation, or of punishment and incapacity, with hypochondriasis; and finally melancholia with stupor and occasional periods of excitement and cataleptoid conditions. Of these types the simple mental exaltation and the simple mental depression are distinct from all other forms of mania and melancholia and can be regarded as pathognomonic of the disease. The other types are not. The disease usually appears between the ages of fifteen and twenty-five with a period of depression, and at the onset is more often of the periodic type, *i.e.*, with prolonged lucid intervals. The lucid intervals as well as the periods of depression and of exaltation may be of varying duration from one or more days to months or years. In a few cases the

duration of the periods presents a marked regularity, so that there is a daily, weekly, monthly, semiannual, or yearly alternation between excitement and depression. This has given rise to the special term, circular insanity of the alternating type. The transition from one period to another may be gradual or sudden.

The prognosis of the disease is unfavorable in view of the tendency to recurrence of the attacks, yet only two or three attacks may occur in a lifetime and terminate in recovery. On the other hand, dementia does not occur, or at least not until late in life or after very many attacks. In spite of frequent recurrence of periods of excitement and depression the intellect remains unimpaired in the intermissions and the patients are capable of successful employment. Furthermore the longevity of the patients is but very little influenced by the disease, although a few patients succumb during the height of the disease as the result of self-inflicted injuries, exhaustion from excessive excitement, and from suicide. The disease is hereditary. In some cases a tendency for the same form of mental disease to be transmitted to the progeny has been noted. Among the exciting causes the most important are gestation, puerperium, menstrual disturbances, and mental shock.

The above conception of circular insanity as forming a distinct entity has not been acceptable to some psychiatrists including Krafft-Ebing, Spitzka, Berkley, and Kraepelin, who regard it simply as a form of periodical insanity. Kraepelin in his sixth edition goes even further, and abolishes the name of periodical insanity, merging the separate forms, periodical mania, periodical melancholia, and circular insanity into a large group which he calls manic-depressive insanity. In it he discerns certain fundamental symptoms which not only give the disease picture a more definite symptomatology, so that it can be distinguished from all other forms of mental disease presenting symptoms of excitement or depression, but also permit its recognition at the very onset. While the etiology, course, and prognosis of his manic-depressive insanity do not differ materially from that outlined by Meyer, Falret, and Ritti, and described above, the disturbance of the apprehension, memory, judgment, train of thought, emotions and volitions, comprising the symptomatology, as described by Kraepelin in the author's mind justifies this new conception of the disease. Therefore, the reader is referred for a detailed description of manic-depressive insanity to the article on that subject by Dr. August Hoch, who includes in it both periodical insanity and circular insanity.

Congenital Neurasthenia.—This form of mental disturbance appears on a defective constitutional basis and is characterized by a continuous state of ill-humor with perverted tone of feeling, an increased sense of fatigue, indecision of conduct, and a tendency to hypochondria. It is to be distinguished from acquired neurasthenia, which is far more prevalent, arises from nervous exhaustion, and has a better prognosis.

The symptoms of the disease usually appear about the twentieth year, although the patients frequently give evidence of neurotic tendencies from childhood, such as neuroses, hysteria, chorea, etc. A delicate and frail constitution may be the only proof of a degenerate heritage. At this time in life, either as the result of an attempt to assume the more serious responsibilities of life, an emotional shock, or some physical disturbance, especially uterine trouble, or quite independently of any external causes, the patient develops a perverted tone of feeling, becomes ill-humored, looks only on the dark side of life, and shows an increased sense of fatigue and a tendency to hypochondria.

He becomes very susceptible to the cares and misfortunes of life, is easily discouraged, and feels that he is of little account in the world. There is often a complaint of nervousness or fear of some chronic disease. Pressure or pain in the head or peculiar sensations in all parts of the body, and many other hypochondriacal ideas, as well as insomnia, are prominent symptoms. The hypochondriacal whims may become even more prominent, giving rise to apprehension of death. Some patients are constantly talking of death and even making preparations for it. They are sorrowful and gloomy, any possible present happiness is clouded by past sorrow or fears for the future.

The greatly increased sense of fatigue interferes with regular employment. The patients are perfectly capable of taking up a piece of work with intelligence and skill, but they tire easily and demand frequent rests. Continued application causes headache, insomnia, and malaise. Furthermore, they are very easily distracted; very trifling events divert the attention and lead to frequent interruptions in the work. While some patients present a characteristic indecision in conduct and frequent change of purpose, others are painfully deliberate in all their actions and show extreme precision and punctuality in little things. The intellect remains unimpaired. There is no disturbance of apprehension, and thought is coherent. Many patients are conscious of their unfortunate state.

There are a few cases of congenital neurasthenia, which not only present the sad and ill-humored disposition, but also show an increased egotism with a corresponding disregard for the feelings of others. These patients are sensitive, fault-finding, quarrelsome and distrustful, sometimes tractable, but more often stubborn and even aggressive.

The disease when once established continues throughout life. At first there may be remissions, but even during these the patients are apt to show peculiarities.

In the matter of treatment, the patients may be made very comfortable by a well-regulated life with suitable environment. On the other hand, family strife and increased responsibilities tend to diminish the chance for improvement, while undue sympathy with absence of restraint is deleterious. Suitable employment which can be so adjusted as to increase gradually the expenditure of energy and responsibility is most helpful. Massage and gymnastics are of value in inducing new energy for work and in establishing self-dependence. Hypnotic suggestion may help in relieving insomnia and imaginary complaints.

Hypochondriacal Insanity (*Hypochondriasis*).—The term hypochondriasis is, with melancholia, one of the relics of the age of Hippocrates and Galen, but, like melancholia, it has suffered many changes in definition from time to time, and has now become so limited in its application as to fail even of recognition at the hands of some clinicians. The term is still much used by the general practitioner to represent that peculiar condition in which patients present an abnormal tendency to dwell upon trifling symptoms of an indefinite and apparently chronic ailment. Many psychiatrists (Kraepelin, Pitres, Kirchoff, Tuczek), on the other hand, regard it only as a symptom of an abnormal mental state, and place it as one of the manifestations of some psychosis, especially neurasthenia, and also melancholia, paranoia, and paresis. But there still remains a small group of cases characterized according to Boettiger, Romberg, and Hitzig by a continual emotional depression depending upon a morbid alteration of self-perception, leading to concentration of the attention upon self and a domination of thought by ideas of physical disease with a corresponding limitation and poverty of thought in reference to matters external to self, and a resultant interference with mental application, without a tendency to profound mental deterioration.

Some writers (Gowers) maintain that hypochondriasis is not a form of insanity, making the arbitrary distinction that the ideas of physical disease should not pass the boundaries of that which is physically possible and should be reasonable. This contention is hardly tenable, however, in view of the fact that the false ideas of the existence of disease do not have an adequate basis in morbid organic changes in the body and cannot be reasoned away, so must be regarded as delusions.

Undoubtedly the abnormal mental state arises either primarily from a morbid functional change in the brain

or secondarily following some sort of an abnormal sensation in the peripheral sense organs. It is thus seen that the disease approaches closely the constitutional psychoneuroses and, in common with them, finds its most prominent etiological factor in a defective constitutional basis. The disease, however, sometimes appears in individuals without this defective basis, in which cases it has been called acquired hypochondriasis in contradistinction to the temperamental forms (Gowers). The only clinical difference in these two forms is that, in the acquired, the symptoms are episodic and have a good prognosis, while in the temperamental form the disease appears earlier in life and presents a continuous course throughout life with remissions and exacerbations (Krafft-Ebing). The disease may appear at any time from youth to old age. Exciting causes are usually present in the form of some physical disturbance, although this is most often of a very trifling nature, such as a moderate chronic gastric catarrh. The disease often follows persistent ill-health.

The patient conceives the idea that he is suffering from some physical disease. His attention in most cases is attracted to some gastric or intestinal disturbance, which for some time may have been causing him distress after eating; but now, the distress is more or less constant and extends over the whole abdomen, creating great discomfort and unfitting him for work. In connection with this the "nerves of the leg tingle" and a cold perspiration appears over the whole body. The appetite fails and the bowels constantly rumble. There is a peculiar sensation at micturition and the urine is highly colored. The altered and illusionary perception of these numerous sensations increases with the concentration of the attention upon the self, until finally every organ of the body is involved and gives rise to the idea that the patient is suffering from some terrible disease. A patient whose hypochondriacal ideas originated from headache, in describing her symptoms said: "I have such a distressed feeling in my head all of the time. Sometimes it feels as though it would crack open, sometimes as if a tight band were about it, or as if it had all shrunken up. Yesterday it felt numb all day. I can hardly see with either eye because of the pain. I have not read a book or written a letter for a long time because of this pain and have stayed in a darkened room for days. I have no control over my eyes and cannot look at an object long at a time. For some time I could not smell anything. It seems to affect my legs, because at times I lose all strength and sensation," etc., etc. Next to dyspeptic disturbances and heart troubles, cephalic sensations are the most common in hypochondriasis, but in the end not an organ or a part of the body remains unaffected.

Such ideas come to occupy the mind exclusively, and then any sort of a trifling sign is interpreted as an additional positive symptom of the dread disease; mere flushing of the face means syphilis, a slight cough is positive evidence of consumption, or a leucorrhœal discharge of cancer of the womb. In search of further evidence of physical dissolution these patients scrutinize their excretions: the fæces for intestinal parasites, the urine for calculi, and the sputa for tubercle bacilli. They begin in the morning by examining the face, eyes, and tongue. After breakfast, they watch for the formation of gas in the intestines and stomach, for irregularities in the stools and urine, and thus the entire day may be passed in self-examination.

As the ideas and the interpretations of these sensations become more and more absurd, the emotional attitude of the patient becomes one of permanent sadness and gloom. In connection with these changes, the ideas of the patient become exclusively egocentric and there develops a corresponding disinterest in the affairs of the outer world.

The hypochondriacal patient has but one purpose and that is to nurse and seek relief for his disordered body, so he goes from one physician to another and runs the whole gamut of the medical profession from the regular school to the osteopath. Mental application and successful employment are impossible except for short intervals, and the patient sooner or later becomes relegated to a life of invalidism.

As already indicated, the course of the disease tends to chronicity, with remissions and periods of exacerbation, except in the few acquired cases. There is no tendency to mental deterioration except the moderate degree resulting from the extreme concentration of the attention upon the self, and the progressive narrowing of ideas relative to matters outside of self.

The recognition of hypochondriasis is difficult only in cases of acquired and congenital neurasthenia and when hypochondriacal ideas appear as prodromal symptoms in certain forms of insanity. The boundary between acquired neurasthenia and hypochondriasis is sometimes very indistinct, especially in those cases of neurasthenia in which hypochondriacal ideas are very prominent. In the latter, we have more prominent exciting causes in the form of exhausting influences, greater irritability, with difficulty of thought and of mental application. In congenital neurasthenia there is also greater irritability, increased susceptibility to fatigue and emotiona despondency independent of hypochondriacal ideas. In the prodromal stages of melancholia, dementia præcox, and paranoia, in which hypochondriacal ideas may be a prominent symptom, differentiation is difficult and depends upon the presence of delusional ideas which extend beyond the patient's own body and involve the outer world. In melancholia these ideas may dominate the clinical picture, giving rise to a special form called "hypochondriacal melancholia," but here the delusional ideas soon become very absurd and pass beyond the limits of possibility. The patients complain that organs have been removed, the intestines or throat occluded so that food no longer passes, and the brain transformed into sawdust, etc. The author believes that that class of cases, characterized by hypochondriacal ideas of a sexual nature, which eventually end in mental deterioration should be included in dementia præcox. Some have regarded these cases as a special form of hypochondriasis with an unfavorable prognosis. Other forms of insanity, in which hypochondriacal ideas may appear as one of the symptoms, are paresis, epileptic and hysterical insanities, and manic-depressive insanity. In the early stages of hypochondriasis, it is necessary to eliminate the possibility of the existence of some organic disease.

In treatment, naturally an effort should first be made to correct diseased conditions of the viscera, should any exist, but one should not be over-zealous in making exploratory incisions or in removing innocent organs unless definite objective symptoms can be demonstrated. In this way temporary relief may be afforded, but sooner or later the sensations return in some other field with equal intensity. In a recent case which came to the author's attention, a patient during fourteen years had had her eyes examined and refitted to glasses many times, had undergone a uterine operation, and was contemplating an exploratory trephining of the skull for brain tumor.

Constitutional treatment should be directed toward the improvement of general nutrition. An attempt should be made to break down the morbid self-concentration by distracting influences, such as occupation, exercise, and amusement. The symptoms are only aggravated by the ennui of an idle life. Furthermore, the physician must obtain the confidence of his patient at the outset, which he cannot do if he belittles his sufferings or discredits the supposed symptoms. One may later, by the aid of suggestive therapeutics, depreciate these symptoms. Indeed, this method of treatment offers the greatest hope for permanent improvement.

Compulsive Insanity (*Imperative Concepts**).—In the constitutional psychopathic states described here, compulsive ideas overwhelm the patient, inhibit thought, dominate emotions, and often lead to compulsive acts. Compulsive ideas may appear as episodal symptoms in some nervous diseases and especially melancholia of in-

* Imperative ideas, obsessions, impulsions intellectuels, Zwangsirresein.

volution and manic-depressive insanity, but here they infect the entire psychic personality and interfere with mental life in all directions.

There are usually no prodromal symptoms, although the patients may have already given evidence of their psychopathic constitution, by the previous existence of either hysterical symptoms or congenital neurasthenia. The first symptoms very often appear during puberty. Later, they may follow some emotional shock or exhausting disease, lactation or sexual excesses.

The compulsive idea at the onset may be of the simplest sort, recurring spontaneously and unaccompanied by any emotions. The occasional morbid persistence of an idea in a normal individual, such as a popular air, which continues to run through his mind to his great annoyance, would represent ideas of this type. In the patient, on the other hand, in spite of all efforts of the will to dispel them, the ideas persist with morbid intensity, and interfere with the train of thought. At first the patient may be annoyed only by the constant repetition of these ideas. Sooner or later the compulsive ideas take on a specific form, such as the compulsion to ponder over names, the fear of definite objects, etc. The immediate cause of these concrete compulsive ideas can rarely be determined, though sometimes their origin can be traced to something heard or read.

The variety of compulsive ideas is limited only by ideation itself, which fact accounts for the invention of a great many names for the different forms of compulsive insanity in which some one idea has been the most prominent. In general, they may be divided into two large groups; the compulsive ideas manifesting indecision and doubt and those characterized by fear—the phobias.

In the former class, called Grübelsucht by Westphal and by the French maladie du doute, the patients are disturbed by doubts and indecisions of all sorts. Some are troubled by such ideas as, "Who is God?" "Is there really a devil?" "Why is this tree planted here and that house situated there?" Others ponder over the names of persons whom they have met, or the countenance and color of eyes or hair of strangers whom they have passed on the street. Such thoughts busy them much of the time. If there is difficulty in recalling the name, the color of the hair, etc., every nerve may be strained, business abandoned, and sleepless hours devoted to the task, and there is no relief until their efforts are successful. Still others enumerate objects in their environment, the number of the flags in the pavement, the number of trees along the street, the number of spoons on the table, etc. A patient who came to consult Legrande du Saulle cried out upon departing: "You have forty books on your table and wear a waistcoat with seven buttons. Excuse me, it is involuntary. I have to count."

Some compulsive ideas are more trivial and create less doubt; for instance, some are compelled to contemplate the sexual organs of those about them, but ideas of a very simple sort may in time so thoroughly engross the thoughts of the patients that they are unfit for any duty. M. Ball describes the case of an intelligent student who, after hearing some companions talk about the mysterious fatality connected with the number thirteen, thought how deplorable it would be if God should be thirteen. At first he attached no importance to this absurd conception, but he could not prevent himself thinking of it continually and saying to himself, "God thirteen." This later was extended to "eternity thirteen," and then "the infinite thirteen." The constant repetition of these finally made study impossible, and shortly he was forced to give up all employment and was permanently relegated to a life of uselessness.

In the compulsive ideas of fear, the fears may arise in reference to objects, to places, diseases, etc. Perhaps the best known of these fears is the fear of places (agoraphobia), in which it seems impossible for the patient to be alone on the street or in a broad space, or again in a narrow space, as a small room. Hammond reports the case of a man who would not go into the street unless he went in a carriage and while in passing from the vehicle to the door of the house, he required the support of two men. In his apartments at his hotel he walked freely and would go up and down stairs without difficulty. As soon, however, as he found himself on the doorstep his terrors began. It seemed to him that everything was in motion, and it would be impossible for him to live another minute unless assistance were given him. At the same time, his brain appeared to be in motion within his skull, a cold sweat broke out over his body, his heart palpitated violently, his arms and legs trembled with fear, and every now and then a severe spasm would seize him.

Other patients fear being alone (monophobia). In a case of my own of this kind the patient at first developed the fear of being alone, accompanied by all the characteristic physical discomforts, and for one year required the constant attendance of one of her daughters. Later she developed the fear of finding pins and pricking herself, which necessitated her relinquishing a part of her household duties. In washing dishes, she had the constant fear that pins might be in the dish-water. This increased until she feared placing pins in food, and this with the fear of poisoning food absolutely prevented her from doing any work in the kitchen. In addition, she developed the fear of turning on the gas unlighted, and this in turn prevented her from passing through any room where there was a gas jet within reach.

Some patients fear height and cannot stand near the edge of a tall building, cross high bridges, or attend theatres. Others fear dark places, cannot pass through tunnels, or enter dark passageways. These patients take no pleasure in travelling, remain away from the theatre or always sit near the door, ready to fly at the first sign of danger. Some patients fear embarrassment or blushing in the presence of others, which may be so extreme as to prevent social intercourse altogether. Fear may arise upon donning new clothes, accompanied by a feeling of great discomfort, which may prevent patients from ever wearing new garments.

The fear of dirt, contagion, or infection is also a prominent form of compulsive insanity (mysophobia). The countless bacteria constantly present in the air are one of the chief sources of annoyance, compelling patients to handle everything with gloves or to wash themselves and their clothing continually. Hammond mentions a young woman who was shocked by an accidental infection with lice and from that time insisted upon repeated washing of her head with disinfectants. From this as a starting-point, little by little the idea became rooted that she could not escape sources of contamination and that others might defile her. So scrupulous did she become, especially in regard to children, that she would not allow a child to touch or even approach her closely. In the streets she carefully gathered her skirts about her upon passing any one. Each day hours were spent in scrutinizing and cleansing her combs and brushes, and she was known by actual count to wash her hands two hundred times daily. Fear of contamination of the soap compelled her to rinse her hands in pure water, and then the fear of the towel necessitated her letting her hands dry without wiping. In removing her clothing at night she avoided touching it, because she could not have an opportunity of cleansing her hands, so she had some one loosen it and allowed it to drop off.

Books and money are special sources of contagion. Some patients are always afraid of throwing away something of value, and for this reason spend much time in looking over papers and other objects before casting them aside. Such fear may even prevent patients touching anything of value. Others have fear of not doing things correctly, and so are always turning back to see if they securely fastened the door, tearing open letters to see that they enclosed the correct one, or following up friends with whom they have been conversing to insure themselves that they have been understood.

Compulsive ideas and fears are regularly accompanied by various physical symptoms, such as palpitation of the heart, nausea, faintness, pallor, trembling, cold sweat,

polyuria, weakness of the legs, and finally the patients may even lose control of themselves and collapse completely.

Consciousness remains unclouded and there is no tendency toward intellectual deterioration. The intellect may even be unusually good. The patients always possess insight into their unfortunate condition, and the desire, but not the strength, to free themselves from it. Compulsive ideas are usually accompanied by states of lively emotional excitement and as already seen lead to compulsory acts, whose accomplishment is usually followed by a feeling of great relief. In behavior the patients often show nothing abnormal and control themselves perfectly in the presence of strangers.

In the milder forms of the disease the compulsive ideas and fears involve only one field of activity, but in the severer forms every action of the patient is influenced. Doubts are constantly arising as to whether something was properly done, which leads to an ever-increasing painstaking in all the little details of daily life. The whole life becomes one continual round of trouble, anxiety, and fear. The course of the disease varies much. Remissions are common, but the symptoms seldom disappear entirely. Rapid improvement is often noticed. The symptoms often occur in crises. The treatment of compulsive and impulsive insanities are given together under the latter disease.

Impulsive Insanity.—Morbid impulses are regarded by many as only one of the episodal symptoms of degeneracy either allied to or forming a part of compulsive insanity; but according to Kraepelin they are to be distinguished from compulsive ideas in that they appear suddenly, are executed rapidly without the least effort toward resistance, and are regarded as the natural expressions of consciousness at that moment. They do not appear gradually, but are instantaneous, simulating an epileptic equivalent except that there is no clouding of consciousness. These impulses appear without cause, are motiveless, and perpetrated against the ideas and wishes of the patient. In compulsive insanity the patient recognizes beforehand the morbidity of the act and has a chance to resist it, while a feeling of anxiety accompanies the act whose performance brings a sense of relief. In impulsive insanity the act is not accompanied by a feeling of relief, but rather by a feeling of great remorse. Morbid impulses occasionally appear in normal life, when they are usually of a very simple type and occasion no anxiety to the patient; but when they recur constantly, involve the environment and interfere with employment, they indicate a morbid condition of the mental life.

Morbid impulses may assume almost any character, varying from an impulse to touch a certain tree to an impulse to commit murder. However, in individual cases the impulses are usually of a specific character. This tendency to involve only some one action has given rise to several different forms of impulsive insanity, such as the impulse to burn things (pyromania). The best known forms of impulsive insanity besides pyromania are: the impulse to steal (kleptomania), the impulse to drink (dipsomania), the impulse to commit suicide (suicidal mania), and the impulse to kill (homicidal mania).

Pyromania occurs mostly in women, particularly during the age of puberty, for which reason it has been suggested that it may depend upon an irregular development of the sexual functions. A tendency to irascibility and moroseness in the patients has been noted. Cases of true pyromania are rare.

Kleptomania also occurs most frequently among women, particularly during puberty and the climacterium. It is a notable fact that the stolen articles are often useless to the patient, or quite insignificant and sometimes some one article is accumulated in large quantities. Hammond reports that a patient suffering from kleptomania came to him for consultation, and during her visit stole several books, which she returned several days later with an excuse for her act.

In dipsomania, which according to Kraepelin should be regarded as an epileptic state, there arises, after a few days of insomnia, anorexia, etc., an irresistible impulse to drink and indulge in other excesses. In spite of their lucidity, the patients drop everything in a "mad rush" for drink, which is unsatiated until all money is gone and even clothes from their backs are sold to obtain liquor. Not alone alcohol, but anything strong and intoxicating is imbibed, even to drugs and poisons. These attacks, which rarely last over a couple of weeks, are followed by a short depression and a feeling of remorse. They occur only at irregular intervals and between the attacks the patients are not only temperate but may even display an extreme distaste for liquors.

Homicidal mania and suicidal mania differ from the other forms in that both often exist in the same individual. Suicidal mania, in which the impulse is sudden and unpremeditated, must not be confounded with the attempts to take one's life as the result of sorrow or misfortune and after a more or less logical course of reasoning. The act may be traced to the sight or the description of a suicide. The hereditary transmission of suicidal impulses is not uncommon. It is not at all unusual that one of the parents of the patient should have similar impulses and even at the same time of life. Several cases have been reported in which whole families have been afflicted.

In homicidal mania there is an irresistible impulse to kill some one without motive. Fortunately such impulses are rare. According to the views of some writers they never exist independently of a psychosis, in which there are other evidences of insanity, but that they really do has been established beyond a doubt by Hammond and others. Sometimes these impulses arise at the sight of a weapon or a helpless creature. Probably the perpetrators of the Whitehall and similar crimes were individuals suffering from such morbid impulses.

These impulses which occur in impulsive insanity should not be confounded with those accompanying compulsive ideas in which the patient, realizing the enormity of the crime, struggles to overcome the impulse, rushes away from his victim, or throws aside the weapon. A case of this sort is reported by Hammond, in which the patient for months had the compulsive idea to stab his niece with a pitchfork, which at first he was able to overcome. It, however, continued to appear, and each time he approached nearer and nearer his object until he felt that he could no longer resist and so hurried away to the physician for aid. Such impulses are often associated with sexual impulses, indeed they seem to bear a close relation to those morbid sexual impulses which impel patients to snip women's hair, slash dresses, steal women's apparel, etc.

According to many, impulsive insanity should also include the morbid sexual impulses called masochism, sadism, and fetischism, which have been so thoroughly studied by Krafft-Ebing and Schrenk-Notzing, but which the author is unable to discuss here because of limited space.

The intellect of the patients is usually unimpaired, and may even be above the average, but a few cases are accompanied by some mental defect. The patients usually express a keen insight into their deplorable condition and often warn those about them of their weakness. There are often defects in other fields of the psychic life indicative of degeneracy, such as neuroses, hysterical symptoms, etc.

The symptoms of the disease appear mostly during puberty and the climacterium, at which times there is usually diminished power of resistance, both mental and physical. Occasionally periodicity is noticed. Marked improvement often accompanies the development of manhood and the establishment of a stable personality.

The treatment of compulsive and impulsive insanities is limited to physical and mental training and to suggestion. During development, if any of the milder symptoms of degeneracy become apparent, careful attention should be paid to physical training. Later the individual symptoms should be combated by patient and persistent training with a view toward strengthening self-confi-

dence. The significance of the illness should always be made clear to the patients and they should be impressed with the fact that they will overcome it more by abstraction and diversion than by the exercise of will power. The symptoms always tend to become aggravated during periods of physical ill-health, accompanied by debility, anæmia, etc. At such times improvement follows the use of iron, phosphates, arsenic, strychnine, or other alteratives. Removal from home environment to hospital surroundings with its strict regimen often ameliorates the symptoms. Massage and electricity are useful adjuvants in improving the physical and mental tone. The value of suggestion and hypnotism is questioned by some who hold that the disease is absolutely incurable. There is, however, no doubt that suggestion is of value in those cases occurring in acquired neurasthenia or during convalescence from acute diseases in which degeneracy is not so prominent a factor. Finally, the patients must be warned against the use of alcohol, to which they seem to be especially susceptible.

Contrary Sexual Instincts.—This form of the insanity of degeneracy, which received its name from Westphal and since has been exhaustively described by Krafft-Ebing, Moll, and Schrenk-Notzing, is characterized by the exhibition of sexual feelings by persons of the same sex for each other and an indifference or an absence of sexual feelings toward the opposite sex.

This morbid condition is not frequently encountered, although the patients themselves assert that it is by no means uncommon. Ulrichs in his own morbid experience claims to have encountered two hundred cases, while one of Krafft-Ebing's patients states that he knew of one hundred and twenty individuals in a town of thirty thousand population, and eighteen and eight in towns respectively of seven thousand and two thousand three hundred. It is more prevalent among theatrical people, especially women comedians, ladies' tailors, and decorators. While Krafft-Ebing claims that this peculiar perversion of the sexual impulse is congenital, it is more probable that the characteristic tendency only is hereditary.

According to Krafft-Ebing the disease occurs in one of two forms, the acquired or the congenital, each of which differs somewhat in mode of onset, character of symptoms, and prognosis. In the acquired form patients early develop marked sexual feelings, which at first are purely hetero-sexual. Later, either spontaneously or as the result of some accidental injurious influence, especially masturbation, homo-sexual feelings appear. These are usually recognized by the patient as morbid and an effort is made to suppress them. In the mildest form there may be a simple reversal of sexual feelings, which, however, remain characteristic of the sex of the patient. If this condition is permitted to develop a permanent transformation of the psychic personality results, in which the feelings change to those of the opposite sex; *i.e.*, the man has the sexual feelings characteristic of the female sex and during sexual intercourse desires only to be the passive agent. The change may go still further when even the physique becomes characteristically feminine; and finally in a few cases the patient may come to believe himself one of the opposite sex, exhibiting a change of personality similar to that encountered in paranoia.

In congenital homosexuality, on the other hand, the perversion of the sexual instinct exists from the first. In the mildest type, psychic hermaphroditism, there are alongside of the homosexual feelings natural sexual feelings for the opposite sex, but these are much weaker and are manifested only periodically. As in the acquired homosexuality the contrary sexual instincts may involve only the sexual life, not affecting the personality of the individual.

In the more marked cases, called "urnings," there exists a total absence of feeling toward and even an abhorrence for the opposite sex, and there is a change of personality similar to that occurring in the acquired forms. Close attachment usually arises between the patient and some one of the same sex, which develops into a passionate friendship with an extravagant display of affection, kisses, embraces, etc., letter writing, gifts, flowers, and exhibitions of jealousy, sometimes even leading to masturbation or other forms of sexual perversion. Such relations may be maintained for years, although changes of affection are more usual. Both individuals are usually homosexual. In some instances the patient is attracted by the mental or physical superiority of the other individual. The question of social inequality is usually disregarded and many are attracted by machinists and especially by soldiers.

All these patients experience pleasurable sexual feelings only toward their own sex. It usually begins with a mere perversion of the sexual feelings; patients feel an inclination toward individuals of the same sex, are attracted by persons of fine physique, desire to be in their presence, and experience a pleasurable feeling if allowed to touch them. Such feelings may exist a long time before perverted sexual indulgence begins. This may occur as the result of seduction. At this time masturbation is often present. Normal heterosexual intercourse, except in the cases of psychic hermaphroditism, becomes distasteful, difficult, and finally impossible. There are, however, many patients, especially among the acquired cases, who, inspired by the desire for a family, marry and successfully perform marital relations, although with difficulty. Such patients succeed in sexual intercourse only by the aid of imagination, perhaps picturing themselves in the embrace of some one of their own sex.

There are often present other evidences of degeneracy, such as an increased sense of fatigue and lack of perseverance with mental work, or neurasthenia, hysteria, or epileptoid states. The imaginative powers of the patients are usually increased and there is often a marked tendency to dream. The intellect is unimpaired except in a few cases. On the other hand, many patients are gifted, but always show a keen sense of appreciation of their own abilities. Emotionally, the patients are apt to be sensitive, irritable, moody, and impressionable, often timid and given to passionate outbursts.

The conduct of these patients is characteristic. The men are effeminate, vain, unstable, distractible, careless, and untrustworthy. When the sexual tendencies are very pronounced, there may be a distinct change of personality; they are effeminate in manner, gait, and countenance; are coquettish, ultra-particular in their attire, try to be in fashion, wear flowers, use cosmetics, and arrange their rooms like a woman's boudoir. Some like to do needlework, others dress in women's attire, padding hips and breasts and affecting a falsetto voice. In extreme cases physical stigmata may accompany the condition; such as, an absence of beard, feminine voice, soft white skin, and well-developed mammæ. The women show a tendency to grow beards, possess deep voices, and in conduct affect in every possible way mannish traits.

Contrary sexual instincts should not be confounded with the homosexuality as practised among prisoners, soldiers, and sailors who are deprived of the opportunity of enjoying normal sexual intercourse, but who always return to normal sexual relations upon regaining freedom, etc.

The treatment is more hopeful in acquired homosexuality, in which masturbation plays such an important part. Here, besides attempting to improve the general nervous condition, and the establishment of a routine in the physical and mental life, an effort should be made to dispel the homosexual feelings and impulses by means of hypnotic suggestion. This is first directed against the increased sexual excitability and masturbation, next against the insensibility of the patient toward his own sex, and a tendency to heterosexual intercourse. The hypnotic influence is acquired slowly. Among the congenital cases there is hope of recovery only when there is psychic hermaphroditism, as some normal sexual desires still remain. Only a few cases of recovery have been reported among urnings. Schrenk-Notzing lays great stress on regular and natural intercourse, but excessive coitus should be avoided.

FOLIE-À-DEUX.—Folie-à-deux is a broad term which has been applied to the occurrence of a mental disturbance in two or more individuals who have been intimately associated with each other.

The difference of opinion among alienists as to what true folie-à-deux constitutes has led to considerable contention, and even yet there is no uniformity of opinion.

Folie-à-deux was first alluded to by Baillarger, but its first accurate description was due to Laseque and Falret (1877), who stated that delusional ideas of one person might be transferred to another, sane individual, but it was necessary that the two should have been intimately associated and free from counterbalancing influences, and that the delusional ideas should present some degree of probability in order that they be accepted. They also noticed that the psychosis in the second individual did not run a typical course, but tended to disappear as soon as the two were separated. These characteristics still form the essential features in one of the three accepted forms of folie-à-deux, which is called imposed insanity of the Laseque-Falret type.

In 1880 Regis called attention to another form of folie-à-deux, simultaneous insanity, in which an identical psychosis, characterized usually by depression, with delusions of persecution, appeared simultaneously in two morbidly predisposed individuals. It was also necessary that the two persons should have been in intimate and persistent contact with each other, and that the psychosis appear directly following accidental causes, usually of a depressive nature. The absence of evidence of mental contagion in the transmission of the psychosis from one person to the other in this form deterred many from accepting it as a form of folie-à-deux. The appearance of the psychosis either simultaneously, or almost so, in twins, described by Ball (1884) and called folie gémellaire, has also been considered a form of simultaneous insanity. In this form the possibility of contagion is even more remote, as the patients may be at a distance from each other at the time of the onset of the psychosis.

Still a third form was indicated by Maradon de Montyel (1881), called communicated insanity. In this form, which differs from the type of Laseque and Falret by the evidence of mental contagion, the second individual accepts the delusional ideas of the first only after prolonged resistance, and the psychosis persists in the second even after the two have been separated. Schoenfeld (1894) would still further limit communicated insanity, under the name of induced insanity, using the term only in those cases in which the psychosis in the first individual is not only the specific cause of the psychosis in the second, but the psychosis in the second should continue to develop independently, present a typical disease picture, even after the two individuals have been separated.

The term folie-à-deux is still in general use, being applied in a broad sense to these three different groups of cases; namely, the imposed insanity of Laseque and Falret, simultaneous insanity of Regis, and communicated or induced insanity. To some authors the first and third groups seem to differ only in the degree of the intensity of the transmission. In imposed insanity, the patient upon whom the insanity is imposed offers but little resistance to the ideas presented by the patient originally insane, and it frequently happens that the morbid influence does not progress even far enough to render the second person really insane. In communicated insanity the second patient offers much resistance and does not really succumb until after a long struggle. Here, furthermore, the transmission progresses so far that the alienation is complete and the patient continues to evolve a typical psychosis. It is for this reason that these two types are here considered under one heading.

In simultaneous insanity, in which the psychosis appears simultaneously in two or more individuals, the important etiological factor is a morbid hereditary predisposition in each patient. It is also absolutely essential that the patients should have been intimately associated with each other before the onset of the attack, living the same sort of life, often in seclusion, deprived of healthful external influences, and sharing the same hopes and fears. The immediate cause for the outbreak is usually an emotional shock, deprivation, or intoxication.

There is no form of psychosis characteristic of simultaneous insanity, although as Regis pointed out the symptoms are more often those of depression with delusions of persecution. Several published cases have presented the clinical picture of manic-depressive insanity, some of exhaustion psychoses, and many of dementia præcox. In the author's own experience forms of dementia præcox have predominated. It is not absolutely essential that both cases should present the same psychosis. A recent case came to the author's attention in which three members of the family were afflicted; two presented the manic-depressive type and the third the picture of dementia præcox. It sometimes happens that one of the two patients acts as a leader, whose edicts the other obeys implicitly.

The prognosis in this form of folie-à-deux is much better than in the others. Usually one member recovers, and often both do. The prospect of recovery depends somewhat upon the promptness with which treatment is instituted after the onset of the psychosis.

The most important indication in treatment is the complete separation of the two patients. Beyond this the treatment is only that indicated for the type of psychosis from which they are suffering.

The phenomena attending the occurrence of folie gémellaire differ in no essential particular from that occurring in simultaneous insanity, except that it is not necessary for the two persons to have been intimately associated. This form is of infrequent occurrence; Sonkhanoff (1900) reports but twenty-nine cases in literature.

In imposed and communicated insanities the psychosis of the first individual is transmitted only after greater or less resistance on the part of the second individual, usually involving considerable time, during which the two are closely associated with each other. In the former the transmission is so incomplete that the second individual does not develop a typical psychosis, the delusional ideas rapidly disappearing after the separation of the two individuals, while in the latter the second person continues even after separation to develop a typical psychosis independently of the first.

In these forms of folie-à-deux, according to Kroener, who collected one hundred and forty-six cases, morbid predisposition is no more essential than in other forms of insanity. The French maintain a different view. Here also it is quite essential that there be a prolonged and absolute intimacy between the two subjects, and the absence of all external relations capable of counterbalancing the morbid conditions. The patients have the same mode of existence and partake of the same interests. Other favorable factors are blood relationship and an intellectual or moral superiority of the original over the second individual. Furthermore, it is necessary that the delusional ideas should have some degree of plausibility or should be at least within the range of possibility in order that they be accepted by the second person.

The form of psychosis characteristic of these types of folie-à-deux is usually paranoia. The permanency of the delusions with a tendency toward systematization and the absence of any clouding of consciousness or mental reduction, makes this form of mental disease most suitable for transmission from one individual to another. The delusions of a paranoiac are also apt to be more plausible.

The prognosis is more favorable in imposed insanity, in which the second individual usually recovers after separation. In communicated insanity, on the other hand, the prognosis, in accord with that of paranoia, is very unfavorable. In view of the fact that one has no means of differentiating the two forms, imposed and communicated insanity, except by the outcome, the prognosis cannot be made until the patients have been separated for some time. As in the other form of folie-à-deux the only specific indication in treatment is immediate and permanent separation.

Moral Imbecility (*Moral Insanity*).—The term "moral insanity" first described by Pritchard in 1835 as "a morbid perversion of the feelings, affections and active powers, without any illusion or erroneous conviction impressed upon the understanding; it sometimes coexists with an apparently unimpaired state of the intellectual faculties," has in recent years fallen into disuse. For many years the term was a bone of contention among alienists and especially jurists, but the difference of opinion did not refer so much to the existence of the clinical picture as it did to whether it should be regarded as a form of genuine mental disease, as a stage in some form of insanity, or simply a defect in mental development. The latter view is now generally accepted, and under the name of moral imbecility are grouped those cases in which individuals from youth up have always displayed a lack of development of the moral nature, while the perceptive and reasoning faculties are but little impaired.

Some authors still believe in the occurrence of moral insanity in individuals who have previously been free from any moral defect. They maintain that it is possible for individuals who up to a certain time have not given any evidence of moral or intellectual impairment, to lose their moral sense independently of either mental depression or exaltation, and in consequence of this diseased moral condition to speak and act immorally. Nevertheless most of these writers admit that this condition is of very infrequent occurrence. Clouston says of the many cases of this sort reported by Pritchard that most of them really belong to simple mania.

The disease usually appears on a defective hereditary basis, especially insanity, alcoholism, and epilepsy in the parents. In the few cases of acquired moral imbecility, intra-uterine disease, severe illness during infancy, head injury, shock or epilepsy during youth may be the prominent etiological factors.

At a very early age the child presents a marked contrast to the other members of the family. In spite of the fact that he may have been subjected to the same moral and intellectual influences, he is nevertheless morally deficient, shows a premature depravity, lies, steals, and exhibits cruelty toward playmates and animals. He, furthermore, is unsusceptible to moral training; severity and kindness alike fail to create natural moral feelings or to correct the depravity. Shuttleworth, in speaking of the inefficacy of moral treatment, recites his experience with three children, who at times would appear models of propriety, while at others they had all the characteristics of little demons. With innocent expression they would positively accomplish the most abominable mischief, and, after meekly acknowledging the error of their ways, would emphasize their apology by a missile flung at the head of the person who had attempted to bring them to penitence. In some cases the symptoms appear for the first time in youth, as the result of head injury or shock, or accompanying epilepsy.

Later, the natural affection for parents and relatives, as well as normal social instincts, fail to appear. The sense of shame is lacking. Patients are unable to distinguish between truth and falsehood, and steal systematically. There is an absolute moral insensibility. The sense of right and justice is lacking. They may commit to memory and recite parrot-like the ten commandments or legal statutes, but these find no response in their moral natures. For them laws are but police instructions, and their transgression simply a disobedience of them. Contact with society or individuals does not lead to an attitude of simple indifference or negation, but to anger, hatred, and a desire for revenge. The lack of altruistic feelings naturally leads to egotism, which these patients usually display to a marked degree.

The perceptive faculty is unimpaired. The patients are logical in thought and possess a good memory, yet upon close observation an intellectual defect is usually discernible in some field. They are either unreasonable or impracticable, unproductive and incapable of steady occupation or unusually impressionable. They may display considerable skill in efforts at concealment, deceit, and in devising excuses, etc., but their craftiness is not adaptable to mental application or regular employment. In some cases the mental enfeeblement is quite apparent. The patients rarely comprehend the meaning of life or the value of material things, especially money, which they lavish like a child. There is a complete absence of insight into their own immorality. As children these patients become the despair of their parents and the terror of the household, because of their idleness, vulgarity, and falsehood; and in youth a disgrace to the family because of their tendency to extravagance, thieving, and vagabondage. They never succeed in any occupation, indeed labor is a burden. Instead, they indulge in all forms of excesses, especially alcoholic and sexual. The appearance and manner are sometimes very deceptive. It has been aptly said that "they may combine the most innocent, sometimes most engaging external appearance, with an inner depth of cunning and iniquity, which must be experienced to be appreciated."

The physical symptoms characteristic of the disease are those so frequently observed in other forms of degeneracy; asymmetries, faulty articulation, choreiform movements, strabismus, a tendency to epilepsy, etc.

Although these defects continue to manifest themselves throughout life, the course of the disease is marked by periods of exacerbation. The processes accompanying puberty often bring the symptoms into more prominence. Later in life alcoholic and sexual excesses tend to produce deterioration, and ultimately a large number of these patients become inmates of penal or charitable institutions. Not infrequently other mental disturbances appear later in life, especially manic-depressive insanity and paranoia.

The prognosis is hopeless. In a few cases in which the moral defect has developed during childhood or puberty in connection with epilepsy or head injury, the symptoms may disappear with the removal of the causes of these conditions.

The diagnosis is a matter of great importance, especially in those cases in which the patients have come in conflict with the law. The mere presence of moral defect is not sufficient, as this may as well be the result of a defective training as of a defect in the organization of the brain. Therefore, it is essential to establish the existence of a congenital defect from which these clinical symptoms have sprung. In establishing the presence of this cerebral anomaly, we have these important factors: a defective heredity, signs of degeneracy in the patient, such as intolerance for alcohol or a tendency to epileptoid conditions; and the appearance of the first signs of moral defect at a time when faulty environment and bad example could not be responsible, and often when the patients are enjoying every advantage of an excellent education. In connection with this we often have the absolute incorrigibility and inaccessibility to any form of correction. The presence of intellectual impairment, as well as emotional irritability, add weight to the diagnosis.

The only hope for successful treatment is in training and education. Yet, as already indicated, one of the fundamental symptoms of the disease is the inaccessibility to methods of training. Kerlin maintained that to educate them only gave them added power for evil, and that they should not be allowed to prey upon society. However, if removed from bad environment at an early age into institutions especially adapted to their care, where they may be restrained and given religious training for a number of years, a few patients will improve, but the vast majority of them will return to old vices as soon as released.

If the disease is acquired on the basis of epilepsy or head injury, it may disappear with improvement of the causes giving rise to these conditions. "These savages in the midst of culture," as Krafft-Ebing puts it, demand for their own as well as the protection of society detention in charitable institutions.

The following is the history of a case of moral imbecility which came to the author's attention five years ago.

The maternal grandmother of the patient was insane, and the maternal grandfather had attempted suicide. Her development both mental and physical was normal until four years of age, at which time she developed a "mean disposition, shown by hatred of her younger brother and sister, whom she constantly annoyed and mistreated. As she grew older she never exhibited the natural affection for her parents; she was never loving, but always disobedient and deceitful." In spite of moral and religious surroundings, religious tendencies never appeared and she never could be relied upon to tell the truth. Before puberty her hateful disposition, intractability, and a tendency to seek immoral associates compelled her parents to send her to a convent. Here at fifteen years of age, her unnatural sexual desires, irregular conduct, moral perversity, and contaminating influence upon her associates necessitated her removal and commitment to the hospital. She was a bright scholar, pleasant and vivacious in manner, engaging in conversation, and possessing a fair knowledge of French and music. These qualities, with her industry, made her a general favorite with her associates. To a chance acquaintance she might appear a model of propriety, but to those with whom she was closely associated there were many evidences of moral depravity. She chose to associate most intimately with those of low moral tone, with whom she was vulgar, at times profane and even boisterous. Her intimacy with some female nurses suggested sexual perversion. She took every available opportunity to flirt or converse with male employees, whose presence seemed to fire her with exhilaration. To the physician she recited the most preposterous stories about her sexual indulgence and alcoholic habits, which were also repeated with even greater exaggeration to her associates. She frequently wrote to friends and relatives letters filled with extravagant and untruthful statements. A few lines from a letter to her former teacher in the convent offers a good illustration. "I was going to write you in some moments that I should be in my right senses to tell you that I had kept my promise, etc. . . . Indeed, I have not forgotten the 'Sacred Heart!' When I am in my right mind, and at other times, I often imagine that I am going through the regular programme of the day. Sometimes I rave in French too. . . . We patients are used to seeing each other out of our minds and we get together and talk very calmly over our mental diseases." During menstruation, which was often painful, she was frequently quite depressed, unhappy, and morose, and at such times would talk of her future and frequently expressed the wish that she were dead. During the three years of residence at the hospital she always positively declared that she had no desire to be moral, and would give herself up to a life of prostitution when released. Six months after her discharge, word was received that she had left her home and started her immoral career.

Allen R. Defendorf.

XXII. INSANITY: PARANOIA.—(Synonyms: *Primaere Verruecktheit;* Chronic Delusional Insanity; Monomania; Reasoning Mania; Progressive Systematized Insanity.)

Paranoia is a psychosis of insidious onset, developing gradually on a defective basis, and is clinically characterized by the progressive evolution of a permanent system of persecutory and expansive delusions (the latter generally leading to a change of personality); retrospective falsifications of memory and hallucinations at some period but without clouding of consciousness, incoherence, or mental deterioration except in judgment, which is biassed by the delusions. The disease is a distinct entity —a continuous process extending throughout life, and may present remissions but no intermissions, although the temporary apparent subsidence of aggressive symptoms may be mistaken for such. It is always primary, and the varied affective disturbances which have been alleged as the cause of a so-called "secondary paranoia" are to be considered as much a part of the disease as the course and outcome.

History.—Paranoia was a term used by the best Greek writers to denote insanity, but apparently was first employed by modern writers in 1764, when Vogel applied it as a collective name to nine different forms of mental disease. Its first application in its modern sense is due to Mendel (1881). The next most important contributions to its elucidation come from French, German, and, later, Italian observers. The term has thus far found little favor in England. Its application by different writers in different lands has shown wide variations, and the varieties have been as numerous, many being based on the age at onset, the character of the delusions and hallucinations, or some particular feature which has led to the formation of a special variety. This has caused much unnecessary confusion, since the term paranoia has thus been made to include psychoses which have no true paranoiac character, or even symptoms which appear only temporarily in them.

For a very full and interesting account of the evolution of the disease-picture, from the "partial insanity" of Boerhaave, Rush, and Kant; the "monomanie intellectuelle" of Esquirol; Lasègue's "mania of persecution"; the "Verruecktheit" of Griesinger, and so on, see Magnan's lectures on "Chronic Delusional Insanity." *

Etiology.—Cases of paranoia comprise about 2 per cent. of admissions to hospitals, although in any one year this proportion may be exceeded or diminished. In the last biennial period at the Connecticut Hospital for the Insane the per cent. was 6.44, all the cases having received thorough examination according to Kraepelin's classification, with demonstration and confirmation at the staff meetings. From the beginning, however, 182 cases have been admitted—a percentage of 1.9. Kraepelin states that more men are affected than women, but here of the above 182 cases only 76 were men.†

Paranoia develops on a defective basis or constitutional neuropathic groundwork. Although the degenerative significance of the disease picture has been doubted, most authors fully accept it. Berkley says: "I have never seen a paranoiac, in whose case a full and complete history could be obtained, that did not have an hereditary history of drunkenness, family neuroses, or actual insanity." In most cases the degeneracy is hereditary (abnormal character, psychoses, constitutional neuroses, or dipsomania in progenitors); while less often it is the result of infantile diseases of brain, defective development of brain or cranium, etc. There may also be a diminished power of resistance in the cortical cells. Tanzi and Riva found heredity in 77 per cent. of cases, disturbances of development in 9.6 per cent., while in the remaining 14 per cent. hereditary influences were not demonstrated, but neither were they excluded.

The defective basis is recognized by peculiar traits in early life—moodiness, dreaminess, reserve, sexual perversions, and often by physical stigmata. Some display marked aptitude for special mental or physical work, but still more show a certain incapacity or lack of perseverance.

The full development of the psychosis usually occurs between the ages of twenty-five and forty, but may take place in youth or even in advanced life. In 182 cases studied by the writer the onset in 77.9 per cent. occurred between the ages of twenty and fifty, and in 37.8 per cent. between thirty and forty. Alleged exciting causes are acute diseases, anæmia, gastro-intestinal affections with accompanying auto-intoxication, uterine diseases, puberty, the climacteric, trauma, excessive mental stress, shock, excesses, business reverses, deprivation, and disappointment.

Pathology.—No definite anatomical basis, except evidences of degeneration or anomalies in the brain, has been demonstrated. Besides vascular anomalies, "skull asymmetry is not infrequent, and corresponding deviations from the normal in the formation of convolutions, bridging of fissures, or an unusual direction of the sulci,

* Amer. Jour. Insan., vols. l. and lii.

† At the Worcester Hospital in 1900 there were admitted 74 cases of paranoic condition, of whom only 24 were men.

are more to be expected than gross lesions. The atypical formations of the convolutions are the most striking features in my autopsies" (Berkley). Krafft-Ebing states that "the lack of coarse anatomical processes explains the fact that the disease does not advance to deterioration, or at least leaves the formal mechanism of judgment and deduction uninjured."

SYMPTOMATOLOGY.—The principal feature is the insidious evolution of a "stable system" of persecutory delusions, often requiring years. "Candidates for paranoia" early manifest abnormalities of character, as reserve, suspicion, egotism, unrestrained imagination, or instability, and are often considered "peculiar." Many present stigmata of degeneration. On this premorbid personality appear distorted perceptions, falsified impressions of the external world, exaggeration of trifles, vague suspicions, and distrust.

Delusions.—The transition to completely developed delusions is slow. Jokes, smiles, newspaper items, sermons, or plays contain hostile references. Everything seems altered; things are misplaced. Patients begin to review their past life in the light of present troubles. They may experience unpleasant bodily sensations which are correlated with their false ideas, and brood over these until their number and intensity increase, and vague suspicions of an intentional persecution become absolute certainty. People watch them, and the most innocent actions are construed into evidences of persecution.

A real wrong may form the premise of false interpretations, which contradict rational experience. Eventually the delusions become fixed and dominate the entire psychic life. Their content corresponds to the endowment, attainments, and social position of the patients. Some are controlled by witches, others possessed, molested for their religion, political influence, or high station; they are poisoned, tortured, driven from business, etc. The causes assigned are as varied as the delusions, but, whatever their nature, all are eventually combined into a perfect mosaic, which neither argument nor opposition can destroy.

With the transition from vague suspicions to "subjective analysis" (Regis) the soil is prepared for the advent of expansive ideas and a resultant change of personality, the seed germinating with an attempt at "explanation." Systematization and explanation weave events of the environment into the delusions, aided by hallucinations and retrospective falsifications of their previous life. Patients now seek to establish a cause for their persecutions. Why are they abused and tortured, their plans thwarted, their business ruined, their health and even life endangered? Are they different from others, chosen of God, of exalted lineage, destined for lofty station? Their enemies must have some object. Insignificant occurrences of earlier life are magnified and brought into logical relation to their present condition. In one patient typhoid delirium foreboded a new birth as the "Immaculate Concept." Whisperings in adjoining rooms, mysterious disguised visitors, and casual resemblances led a man to believe himself the son of Napoleon Second and to assume the name of Eagle. To some, future greatness was foreboded by events apparently trivial, but whose real importance should have been recognized at the time, when they might have assumed their proper rank and thwarted the machinations of their enemies. Patients consider themselves president, commander-in-chief, statesmen, saints, millionaires, inventors, poets, prophets, or at any rate vastly superior to their acquaintances and exalted above them.

Hallucinations.—These are always present at some time, but not always numerous or prominent. Auditory hallucinations are the most common. At first there are only indefinite noises, which are gradually resolved into distinct voices. These may be heard in one ear only, sometimes in both, and sometimes only "inwardly." The language is generally indigenous, but in cultured patients foreign or dead languages may appear. There may be one or many voices, which may or may not be recognized (God, the Virgin Mary, Christ, saints, devils, relatives, strangers, male or female, "the man with the mournful voice," etc.). The words may be denunciatory, threatening, taunting, reviling, profane, and obscene, or encouraging, consoling, and calming. People are overheard plotting all sorts of crimes and violence, even to sexual attacks, poisoning, or murder, and often give the patient no rest. Or the Almighty may cheer them with promises of final victory, boundless power and wealth, exalted station, etc. The content corresponds to the character and endowment of the individual, and the varieties are too numerous to describe. The hallucinations intensify the delusions, and both react not only to each other, but also to new interpretations of current events.

Hallucinations of general feeling, taste, smell, and sight follow auditory hallucinations in order of frequency. Patients may express all sorts of perverted, unpleasant, and painful sensations, from "electricity, magnetism, vibrations, acid sprays, bullets, knives, poisonous powders, etc." Taste may be perverted; there is poison in the food, arsenic in the coffee. Some paranoiacs always prepare their own food, and will not drink except from a common supply. Others smell poisonous or noxious vapors, chloroform, fæcal odors. The rarity of visual halluciations is fortunate, as it diminishes the probability of assaults. In a few cases innumerable hallucinations may persist for many years. One of my patients, a refined and cultivated woman, has been troubled for twenty-five years by auditory and olfactory hallucinations, without perceptible deterioration.

Train of Thought.—This is well ordered, and educated patients in particular display great acumen in their arguments, appeals for redress, statements, and letters. Their premises may be real or imaginary, but in either case the resultant deductions are perfectly coherent, although a morbid transformation of constantly surging percepts and concepts essentially influences their elaboration. What Professor Dodge, of Wesleyan, calls "the interplay of present with past experience" is never abolished, and Dr. Charles W. Page states that "the evidences of the senses are sifted and scanned, but, as the result of some original distortion of mental power, the conclusions drawn therefrom are abnormal. Consequently the system of experience which is built up is in harmony only with the vicious constitutional obliquity of the paranoiac, who will note discrepancies in his statements, and yet be entirely satisfied with fabricated explanations, which convince none but the author." In other words, the progression of ideas is logical, but the standpoints are displaced, the ethical sense is defective, patients see no incongruity between actual and assumed facts, and their delusions persist though their empirical supports collapse. "With all their misconceptions and misconstructions, paranoiacs retain for many years the power of thinking logically and clearly upon subjects other than those which touch their own false impressions" (Berkley).

Judgment shows considerable weakness, since it is biassed by the delusions, and there is marked inaccessibility to arguments. With the emergence of expansive ideas false premises constantly arise which cannot be criticised or corrected, but are accepted and utilized indiscriminately. Perception is usually keen, but often distorted; orientation is always normal, and consciousness clear. Attention is largely directed to matters concerning the ego, and often wanders from matters outside the delusions. Paranoiacs have no genuine insight into their disease, but may present numerous hypochondriacal complaints for which they seek treatment, and which they defend with great ingenuity. They display a monstrous overestimation of self and an exaggerated self-consciousness, as well as a lively feeling of independence.

Memory is good, except for false interpretations of past events which fortify their delusions (retrospective falsifications of memory). At times patients are under a vehement emotional stress, but show no independent emotional disturbances. They know well how to control themselves, and often dissimulate their apprehensions. At first they are despondent, later shy, morose, and irritable, then fearful, and finally angry and vengeful, al-

though a few are resigned or even cheerful. Ultimately most are apt to become consequential, intolerant, or haughty. Many show a remarkable indifference in describing their criminal acts, whose nature and consequences they fully recognize.

Conduct.—This may be so well-ordered that for a long time no suspicion of insanity is entertained. The early seclusiveness of paranoiacs, their suspicions, peculiarities of dress and manner, are regarded as only "eccentricities," even when they begin to complain of abuses. This is partly due to their keen reasoning, and partly to their plausible interpretations. A teacher engaged in controversies with scholars, parents, and committees for fifteen years before her disease was recognized. An excellent artisan left place after place in various towns because he could get no redress for his "wrongs." During this time he was imprisoned several times for assaults.

One patient airs his grievances in the press; another frequently appeals to the authorities for protection; others write to dignitaries, politicians, actresses, and so on, before their sanity is questioned. One woman kept a record of several changes of residence for two years prior to her admission to the hospital, "to escape operations performed on her at night." Many adopt disguises for self-protection, one patient wearing a "Buffalo Bill wig." But disguises or removals give no permanent security. Wherever they go—on land or sea, even "to the uttermost parts of the earth,"—they cannot elude their enemies. If they should slay some, others will take their places; their troubles end only at death.

With the advent of expansive ideas patients may apply for important offices, propose marriage to exalted personages, write books, promote inventions, etc. They neglect business and family, alienate friends, and become callous to all but their own concerns. Some, however, are capable of varied productive work for years, although their activity is often purely mechanical. Everything centres in the ego. They will not, indeed cannot, take advice; meet all objections with an incredulous, superior air, and their convictions remain unshaken. When finally they succeed in an "explanation" they become very dangerous to the community, since they are almost sure to attempt a murderous assault. Since legal redress is impossible they take the law into their own hands. A paranoiac shot at a milkman because "he had poisoned his cattle and bewitched his sister." Another nearly killed an innocent man whom he deemed a secret agent of a hostile government. Presidents, kings, bankers, scientists, physicians, husbands, wives, children, acquaintances, or a casual passer are numbered among the victims of this dangerous class. Often, indeed, the first revelation of paranoia comes from an homicidal attack.

When the disease is legally as well as clinically recognized and patients are committed to a hospital, they may at first conceal their delusions, sometimes for a long time, but sooner or later they "are discovered by their enemies," and finally they may regard the physicians, attendants, or even fellow-patients as "accomplices." Sometimes they bear their "imprisonment" with a certain dignity, and again consider it the culmination of their troubles. As a rule they keep to their rooms and form no associations with others. Their pockets are often stuffed with documents substantiating their claims, copies of legal records, memoranda, and bulky letters. Their correspondence is usually voluminous. Residence in a hospital does not render them less dangerous, and they are always liable to make unexpected and treacherous attacks, especially during exacerbations. More than one physician or attendant has lost his life through careless disregard of this propensity.

Course.—The course of paranoia, when fully established, is progressive and prolonged throughout life. Several stages have been described, to which there is no objection if we bear in mind that there are many variations from the type, that the boundaries are not sharp, and the transitions are often imperceptible.

The *typical* course is as follows: On a defective constitutional basis, evidenced in childhood, youth, or even up to the period of involution by various "peculiarities" already described, sooner or later there arise vague doubts, suspicions, fears, erroneous interpretations, or broodings over matters, often trivial, which a healthy mind would overlook or soon dismiss. Hypochondriacal complaints are apt to occur. Add to these a certain amount of introspection, and we may fittingly call the whole the stage of incubation. This may and often does last for months or even years, and during its continuance patients are never supposed to be more than eccentric or "cranky," unless they come under the observation of a trained physician.

Having gradually passed the border-line of sanity, paranoiacs enter on the second stage—that of delusions and hallucinations. Here the doubts and suspicions are compacted into a delusional structure, which gradually acquires symmetry—one false idea fitting into or leading to another—until a stable system of persecutory delusions is evolved. This is aided by the hallucinations, which are of central origin, are largely auditory (first vague noises, then voices), and increasingly torment the patients. The character of the delusions and hallucinations has already been described.

The third stage may be styled that of "delusional explanation and subjective analysis," with either exaltation or change of personality. While heretofore paranoiacs have partially analyzed and arranged their delusions, perhaps instinctively, they now give them a more complete and logical interpretation. They require a reason for their persecutions, which are so numerous and constant that they must be different from ordinary individuals. They review their whole past, and discover in many occurrences indications that should long ago have convinced them that they were set apart from and superior to their fellows. Their mental ability was greater, their morals were more lofty, their religion was purer, their productive capacity was larger; they had often received special attentions and positions; they recall mysterious or significant visitors; others' trials were due to ordinary causes—theirs to special causes. These retrospective falsifications may be confirmed by the voices, which may now be consoling or prophetic. The question arises: Am I persecuted because I am superior, or am I exalted on account of my persecutions? Whatever the answer, by an ingenious train of reasoning the past and present, delusions and hallucinations, persecutions and exaltation—in short, everything assists in establishing their new, or rather "rightful," personality. The previous intense mental stress is now resolved into a calm assurance, and the "world saviour," the "chosen one," the "Immaculate Concept," the "prophet, priest, or king," the president, statesman, scientist, poet, and so on, appear in their true light and demand recognition. The seeming equability of the patients does not prevent them from forming plans ruthlessly to secure and maintain their "rights," but rather favors them, and they now are even more dangerous than in the second stage. While less obtrusive, they are more treacherous.

The fourth stage is called by Berkley "the stage of quietude, in which a degree of weak-mindedness is apparent on close examination, but in which there is nothing approaching dementia except in a minor number of instances." These latter cases the writer would include under the head of paranoid dementia. Impressions from the external world often fail to reach the patients, whose attention is directed exclusively to their own concerns; or, reaching them, fail to impress. Defendorf says ("Lectures on Psychiatry," Yale Medical School): "After a duration of many years (in one case thirty-five), a moderate amount of mental weakness appears, when patients become incapable of application, take less notice of their environment, and less care of themselves. In some cases the disease may seem to be at a standstill for years, while in others partial remissions occur during which patients may be able to rejoin their family, but are rarely in a condition to resume their accustomed occupation." If allowed to go home they should be carefully watched.

Authors have described several forms of paranoia—

early, late, querulent, erotic, religious, alcoholic, hallucinatory, acute, and chronic—some of which merit a brief notice. There has been a tendency to overdo this subdivision, thus obscuring the general picture. In all forms the *fundamental symptom*—persistent, systematized delusions of persecution—is practically the same, but the picture is colored by various factors. According to my view, paranoia is always chronic and the age at onset immaterial, except that querulency appears later than the other forms, and leads more rapidly to deterioration.

In querulency, first described by Hitzig in 1895, a few cases present sufficient peculiarities to merit description. The psychosis is of gradual onset, the conduct of patients is due to an actual delusion, and the ideas of legal injury are associated with a single, very definite standpoint, to which they always recur. The exciting cause is usually some real event, possibly a legal injustice, an unfair decision or adjustment of claims, or an editorial, all of which are delusionally explained. Hence the patients enter a suit in either civil or criminal courts, or both, and when the decision is adverse carry the case to the highest tribunals, and, failing satisfaction or a "just verdict" from these appeals, apply in person or by letter to magistrates, legislators, cabinet officers, and even the president or king. To confirm their claims they carry about copies of court decisions, voluminous documents, newspaper clippings, etc.

However amenable at first, they soon reach a point where they cannot give any credit or attach any importance to the opinions of others, and in this respect their judgment is entirely biassed or obscured. Their memory is unusually retentive, and they delight to air their legal lore on all occasions. Their conversation and letters teem with legal phrases and quotations. Consciousness is clear and thought coherent, but they show limited ideation by constant and tiresome recurrence to their delusions. While there is usually no change of personality, patients display a heightened self-feeling, a certain optimistic superiority, an over-estimation of self. At the same time they are easily irritated, and shower scurrilous abuse and accusations of injustice, venality, and perjury on all opponents.

There is an increasing enlargement of the delusions, which are deeply rooted in the mental personality and worked up into a system. Hallucinations are rare. A striking feature is the senseless way in which patients neglect their family and business, squander their money on and devote themselves to a cause which does not merit the attention bestowed on it.

Froward, litigious, and even weak-minded persons may sometimes pester the courts in a way similar to that of querulents, but proof of actual delusions on which litigation is based, the complete inaccessibility to instruction or argument, the injudicious conduct, and the persistence of symptoms for years facilitate the differentiation. The limitation of thought may explain the mental deterioration which occurs earlier and is more marked than in other forms of paranoia, but never comes to complete dementia.

In erotic paranoia patients imagine themselves admired or loved by persons of the opposite sex, and usually of higher rank. Their love is romantic and platonic, and may last for years before it is divulged, except by casual meetings or occasional remarks. The most trifling things, such as a nod, smile, rosebud, costume, flight of birds, etc., are mystic or symbolic. The loved one appears at the window as they pass, attends the same church, and gives "significant looks." "All know it, but say nothing directly." The delusions may exist for years before they are betrayed by actions, or the "affinities" are annoyed by attempts at interviews or threats. In all cases the love is believed to be mutual. Where sexual excitement exists it usually assumes the form of perversion or onanism, and is specially intense at night. Hallucinations are infrequent and transitory. When the delusions become fixed and patients obtrusive by interviews, indecent letters, etc., their conduct leads to arrest and commitment to a hospital.

In religious paranoia patients begin to manifest morbid religious tendencies during adolescence. Prolonged abstinence from food, protracted meetings, excessive study of the Bible eventually upset a weak personality. Texts are misapplied or rigidly construed, practice is swamped by theory, works are perverted by misdirected faith, and eventually delusions of inspiration and exaltation arise and develop logically into a system, which gradually assumes a fantastic garb. More women are affected than men. Patients become Messiahs, saints, prophets, or parents of a new and greater Christ. Many have mystical intercourse with Christ, the Virgin, or angels. Some indulge in sexual perversions, and all are more or less erotic. They are the plagues of clergymen and unendurable to the community, which eventually demands their seclusion. They are not very dangerous unless opposed, but occasionally one attempts to sacrifice one or more members of his family by "direct command of God." All are absolutely inaccessible to reasoning.

Alcoholic paranoia is characterized by partially systematized delusions of infidelity, irritability, occasional violence, and homicidal or even suicidal tendencies. Delusions are concealed or denied during hospital residence, but reappear on discharge.

Diagnosis.—This rests upon the evidence of defective endowment, early "peculiarities" of conduct and manner, slow onset, gradual development of a stable system of persecutory delusions, hallucinations, retrospective falsifications of memory, exaltation or change of personality, and violent assaults, with preservation of clear consciousness, coherence, and absence of marked mental deterioration for many years. Persecutory delusions appear in other psychoses, but often are purely episodal, and must always be considered with the course of the disease. Many cases have been classed as pure paranoia which really belong to the paranoid forms of dementia præcox (Kraepelin). In them the onset is more acute, the delusions develop rapidly (often inside a month), their senselessness often transcends the bounds of credibility, they frequently disappear to make room for others, and are largely somatic. Hallucinations are numerous and play an important rôle. There are pronounced sadness or anxiety, abrupt changes of disposition, periods of excitement, and sometimes stupor. There is occasional flightiness, the train of thought is confused, and there is little tendency to harmonize the delusions with the previous life.

Kraepelin distinguishes two groups of paranoid dementia. The first terminates in marked deterioration inside of two years. The second may last for years without much deterioration, there is some attempt at a "system," and the delusions are fantastic—absurd somatic symptoms characterized by neologisms (flesh bulging, blood stilling, heart crack, spectrones, etc.). The thoughts are read, changed, or withdrawn, and there may be two persons in the body—one hostile, the other friendly. The acute hallucinatory paranoia of some writers should be included in these groups, or with alcoholic delusional insanity.

A few cases of dementia paralytica, dementia senilis, and melancholia of involution present a temporary resemblance to paranoia, but can be distinguished by the absence of gradually developed and logically elaborated delusions which permanently dominate the entire psychic life, and by the presence of characteristic physical symptoms, with mental deterioration.

Prognosis.—This is absolutely unfavorable and no genuine case ever ends in recovery, although remissions may occur, which are more apparent than real. Patients, however, are never reduced to a condition of complete dementia, and after very many years display only a moderate blunting of the higher faculties and finer feelings, a moral anergy, a decreasing energy of action and capacity for work, and a limitation of the spheres of interest, which are sometimes mistaken for intellectual defect. Some writers state that involution occurs earlier in paranoiacs, and senility may color their last years by its characteristic anatomical degenerations.

Treatment.—In the fully developed disease it is essential that patients be confined in a hospital, on account of

their menace to the safety of the community. Here the regular routine, occupation, plenty of fresh air, suitable diet, and various diversions may at least postpone mental weakness and partially ameliorate the condition. Unhappily most paranoiacs rebel against confinement, struggle for freedom until their energies are paralyzed, consider every one around them as persecutors, and threaten, plot against, or even attack them. Hence at all times they require careful watching to prevent injuries and fatalities. Drugs are not indicated except an occasional sedative to allay excitement. In the future treatment should be directed more and more to the premorbid, prodromal, and, above all, prenatal factors. If marriage could be regulated, or the hereditarily defective be secluded from early childhood with suitable environment and training, mental, moral, and physical, much might be done to prevent the evolution of this psychosis.

Lack of space precludes discussion of the important medico-legal aspect of paranoia.

James Mortimer Keniston.

XXIII. INSANITY, PUERPERAL.—The term puerperal insanity is descriptive and does not need a definition, but it requires qualification. In the early classifications of mental disturbance names were given to symptom groups to correspond with the disease conditions which apparently gave rise to them. However, we now know that the relationship which was thought to be causative is really only one of association. Tuke's dictionary says: * "There is no special form of insanity which is to be distinguished as puerperal insanity; for though the various symptoms of mental disorder may appear in certain relationships more commonly with puerperal conditions than with others, yet there is nothing really special as to the form of the disorder." Clouston † describes puerperal insanity as a separate form, limited to the first six weeks after confinement. He also says: "By far the majority of cases, and by far the most acute and characteristic cases, occur within the first fortnight." The latter definition, which is the commonly accepted one, suggests that there is an essential relation between the phenomena of parturition and the puerperal state, and the insanity which develops. However, it must be remembered that physical disease during the puerperium, or even severely untoward conditions in the environment of the woman, do not of themselves produce insanity. We have only to recollect under what calamitous conditions women frequently give birth to children, and how commonly infection or auto-intoxication in some form follows labor, and even extreme traumatism, yet there is no mental disturbance. Besides the disturbance or aberration of cerebral functioning and the different factors which stand in apparent causal relation to the manifestations which result, there is to be considered the cerebral potentiality of the individual. The form in which the insanity may be manifested is not the product of any specific cause, resulting in the development of a definite symptom group; but, on the contrary, a process, varying within wide limits as to its intensity and form, depending upon the degree of defect in the individual for its extent, and upon her environment for the nature of its manifestations. It is true that mental aberration is frequently associated with the different developmental epochs in the life of the individual, and in women especially with puberty and maternity. But to say that puberty, the period of adolescence, or maternity, stands in causal relation with any particular form of insanity seems to be an unwarranted deduction, when we take into consideration the fact that all women pass through the epoch of puberty, the period of adolescence, and most women bear children; but only a comparatively small number ever become mentally disturbed as a result. Besides, when mental disturbance does occur, it is most frequent in primiparæ, especially if they have passed the age of thirty years. Then, too, the insanity bears no direct relation to the condition of the mother during the period of gestation, the severity of the labor, the presence of disease during the puerperium, nor the exigencies of the period of lactation. However, mental alienation occurring during any one of these periods does bear a constant relation to the degree of defect in the nervous organization of the woman; and the extent of this defect will determine the character of the insanity, the point in the cycle of maternity at which it will be manifested, its form, nature, and termination. The fact that puerperal insanity occurs most frequently in primiparæ makes the foregoing deduction obvious. The occurrence of insanity after the birth of the first child means simply that the cerebral potentiality of the woman was not equal to the strain of maternity. Even in those cases in which the outbreak of mental disturbance occurs after the birth of other children, the histories of all of the cases coming under our observation show that there was some degree of mental aberration after previous confinements; so that between the primipara and the multipara there is really no difference except as to the degree of instability and possible untoward conditions of environment.

When we stop to consider how women are warring against their natural position in relation to the reproduction of the species, while the competition of social and industrial life and the growing desire to avoid any responsibility which interferes with material advancement or social opportunity is so strong, it is not surprising that we should find so many disturbances of the nervous system associated with the bearing of children; nor that this originally physiological function and process should be credited with the untoward results which so often accompany and follow it. There are probably very few women who enter upon the period of gestation without some misgivings and more or less resentment, because of the physical discomfort connected with their condition, as well as the annoyance resulting from interference with their pleasures and social opportunities. It is certain also, if she has borne children before, that the mental attitude of the woman toward her condition will be largely influenced by personal experience of the discomforts, annoyances, and dangers of maternity. Aside from the occasional woman in whom the function of child-bearing continues to be a physiological process, there is practically always more or less disturbance of health during pregnancy, either physical or mental; and when we remember the intimate association of the nervous system with the functional activity of the reproductive organs in women, and how quickly disturbance in the one is responded to by disturbance in the other, we ought to expect that there would be more or less intimate association of mental disturbance with child-bearing. Again, on the physical side, we have to consider the effect of accident and disease during the period of gestation, complications of the act of parturition, or its excessive prolongation on account of disease in the mother, deformity or malposition of the child.

Following labor are the risks from post-partum hemorrhage, septic infection, and the ill effects of subinvolution; while, during the period of lactation, her inability to nourish both the child and herself, or the strain of its care and attention, in addition to other duties, may seriously affect the health of the mother, and therefore the welfare of the nervous system. The effect of pregnancy upon the nervous system of the woman, and the peculiar susceptibility of women to causes of mental disturbance during the puerperium are so well known, even among the laity, as to have resulted in a definite tradition, with certain conventional rules for the conduct of the pregnant woman and the ordering of her environment during the period of gestation and after labor. These ill effects seem, too, to increase with civilization and its requirements. In other words, along with the increased capacity to enjoy there goes a proportionate tendency to suffer. While frequent child-bearing, overcrowding, and bad surroundings in the tenement districts of the city, exposure and overwork in the country among the poor, bring a train of physical ills to complicate maternity,

* Tuke: "Dictionary of Psychological Medicine," article "Puerperal Insanity."

† Clouston: "Mental Diseases." Lecture 15, "Puerperal Insanity."

high-pressure intellectual life and social competition have an equally disastrous effect upon the well-to-do. So that whatever weakness or defect may exist in the mother is exaggerated by her condition, and what was originally a physiological process becomes a pathological one; out of which develop a host of conditions, most of which are temporary, but often they destroy the physical or mental health of the woman.

It is seldom, however, that the woman is both physically and mentally ill at the same time. On the contrary, it is quite infrequent to find mental disturbance, other than delirium, associated with the accidents of labor or with septicæmia; while the victim of the insanity of pregnancy, as a rule, has a normal labor and puerperium. It is true that the pregnant or parturient woman is frequently hysterical and neurasthenic, because of nervous instability brought about by untoward conditions in her environment, operating during the cycle of maternity; and there may and do develop marked changes in her character and disposition, but these disturbances disappear after the birth of the child. The various disturbances associated with maternity simply prove what we know to be a physiological fact—that is, the intimate association between the function of reproduction and the activities of the rest of the organism,—while the greater instability of the nervous system in women renders conspicuous and prominent those changes which the concentration of her vital forces in the process of reproduction makes possible and renders apparent; because under modern social conditions the nervous system is not equal to the task of controlling its own manifestations and meeting the extra demands upon it.

It is probable that those women who become insane during the puerperium have also manifested some sign of mental disturbance during the period of gestation; but it has been overlooked because domestic tradition makes those familiar with the individual expect some departure from the normal and usual habits of the woman, and the changes in her character and conduct are attributed to anything but the real cause.

We have never found anything peculiar or distinctive in the manifestations of mental aberration associated with maternity. It is true that more women recover who become insane in connection with maternity, and this is especially true of the large number of cases which for obvious reasons are not committed to hospitals for the insane. But these cases are almost always ones of acute delirium or confusion, the mental disturbance being consecutive to exhaustion of vitality, insomnia, shock, or septicæmia; and it may be questioned whether the confusion and delirium in these cases are really insanity. We have noted, in studying the case records of over three thousand women, that outside of the degenerations taking place during the periods of adolescence, the climacteric, and senescence, the insanity of the rest of the women was practically always in some way related to maternity. It is not surprising, when we consider the marked influence of pregnancy and maternity upon the life processes in women, and the demand they make upon the nervous system, especially in primiparæ, that any instability or defect should become conspicuous; or that if the former be marked the nervous system should be unbalanced, while in the latter the strain should be the starting-point for the degenerative process. There are very few women who do not suffer from depression and irritability during pregnancy, and perverted appetite is quite common; while some, even in whom there is no other manifestation of aberration, will suffer from perversion of some one of the special senses—usually in the form of olfactory or gustatory hallucination. Then there are the morbid self-consciousness and the different forms of unreasoning fear, jealousy, suspicion, and emotional outbreaks. Now if these disturbances occur in the average woman, it is not surprising that they should be exaggerated in the unstable, or become the starting-point for progressive degeneration in the defective. In the simplest form of puerperal insanity there is usually the addition of confusion and loss of control to what are considered the ordinary nervous disturbances associated with the puerperal state. In others the patient passes from confusion into delirium. However, this delirium is not really a part of the insanity, but is superadded to it, and always has for its antecedents exhaustion of vitality, insomnia, and impaired nutrition. Therefore delirium may occur in the course of any acute insanity, if the conditions which give rise to it are present.

As a rule those women who have been despondent during the period of gestation, and are afterward insane, become excited; while those who have been irritable, hysterical, or exalted become depressed. In some cases, instead of recovery following, the delirium subsides into maniacal excitement; the patient who is depressed becomes suicidal, or manifests homicidal impulse toward the child. Again, the woman becomes the victim of religiosity, with grandiose or depreciatory ideas which govern her conduct; or she may develop auditory hallucination, to be followed by persecutory ideas. Sometimes there is simply progressive mental reduction, with the furtive suspicion, obstinacy, and explosive outbreaks of violence characteristic of the animal. Of course, there are infinite variations in these manifestations; but whatever form the disturbance assumes, it will be found to be related to a definite degree of instability or defect in the individual: the simplest form of mental disturbance being associated with brain instability, while the graver manifestations are associated with defective development, and are proportioned to the degree of defect, as shown by the heredity and corresponding limitation of cerebral potentiality.

This being the case, in considering both the diagnosis and treatment of puerperal insanity, as well as the prognosis, we are dependent more upon the life history of the patient than upon her mental state or immediate physical condition. Furthermore, aside from its influence on the method to be adopted for the management of the patient, we are not concerned with the form in which the mental disturbance is manifested. It is unfortunate that the noise she may make and her excessive motor activity, which are of no importance so far as prognosis and treatment are concerned, should occupy so much of the time and attention of the physician and family, to the exclusion of the proper study of the physical conditions present and the restoration of the self-control which the patient has lost.

In the presence of the acute forms of mental disturbance, we have to determine the physical conditions to which they are consecutive. They usually have for their immediate antecedents exhaustion, constipation, and insomnia; and these conditions may have antedated the birth of the child, the strain of labor being the final cause of the upset of an unstable nervous system, or there may have been infection after labor, and the consequent septicæmia has been the exciting cause of the conditions which precede the acute outbreak. Again, none of these physical manifestations may be present, but the woman may be restless and uneasy after her confinement, sleep poorly, and take but little food. About the third day or later, she will suddenly break out in a fit of explosive laughter or convulsive weeping, and these outbreaks may be followed by violent maniacal excitement, or are preliminary to the progressive development of stupor. If the outbreak is one of excitement, the woman becomes hilarious, shouts and sings, and if not restrained dances about the room, disrobes or tears off her clothing, refuses food, does not sleep, but apparently does not lose either in weight or strength. She may be passionately attentive to the child, utterly indifferent, or violently antipathetic; and these various attitudes may also be maintained toward her husband and family. This exaltation may keep up for some time, then gradually subside; or the exaltation may be followed by great emotional disturbance. The woman will sob convulsively, throw herself about in bed, express great fear and anxiety, cling closely to her husband, relative, or the nurse. Again she may shrink from all those who have been closely associated with her. If this emotional outburst is followed by

quiet sleep, the prospect for recovery is good; but if, on the contrary, these extreme mental states alternate, only a little food is taken, sleep is broken or absent, and especially if the woman becomes lascivious in her conversation and conduct, it is probable that the outbreak is but the beginning of a progressive degenerative change, and that, at best, recovery will be only partial. The most hopeless form of puerperal insanity begins very insidiously. Usually there is nothing to attract the attention of those about the patient except progressive indifference to the child, furtive suspicion, disinclination to talk, restlessness and a disposition to pick or pull things to pieces. One woman was apparently free from mental disturbance, yet whenever she could get hold of a pair of scissors she would begin to cut up the bed clothing or her own. When stopped she would laugh, appear momentarily confused, then apparently forget that she had done anything out of the way. There may be sudden aversion to the child, or jealousy of the husband with suicidal impulse. (It is a safe general rule to regard all puerperal women who are insane as liable to harm the child, no matter how apparently affectionate they may be.) There is another class of cases in which the woman becomes confused and suspicious, gradually lapses into stupor, becomes filthy in her habits, does not take food voluntarily; the tongue becomes swollen and heavily coated, the breath foul, the extremities become cool and clammy. This condition may continue for a long period without change, be followed by recovery, or partial restoration with final lapse into dementia. These are cases of profound trophic disturbance, probably due to autointoxication, apparently from paresis of function in the vegetative organs, and especially those concerned in elimination.

The treatment of puerperal insanity resolves itself into a consideration of the conditions, both physical and mental, under which it exists. Acute and apparently sudden outbreaks of mental aberration during the puerperium suggest the probability that some somatic disturbance exists, or that something untoward has developed in the environment of the patient. In those forms of insanity, however, which are gradual in their onset, and not marked by any conspicuous manifestation of mental disturbance, the presumption in favor of an immediate exciting cause in the state of the patient is not warranted, and careful investigation must be made as to the phenomena of the period of gestation, for the possible presence of some diathetic condition, as to the life history of the woman, and these investigations are especially necessary when we have to consider the prognosis.

While the immediate exciting cause of the mental disturbance in the puerperal woman may have an important bearing upon her physical welfare, and therefore indirectly upon the progress of the insanity, it does not affect the prognosis as to recovery from the mental disturbance. The *prognosis* in any given case of insanity connected with maternity is, other things being equal, dependent upon the heredity and cerebral potentiality of the woman. Further, those cases having an heredity of insanity alone, or a neurotic heredity, are most likely to recover, while those having an heredity of consumption, alcoholism, syphilis, or cancer are the most certain to be the victims of progressive degenerative change. Or, to express the same conclusion in another way, the children of the neurotic and insane are unstable, while the children of those suffering from somatic disease which seriously impairs vitality are defective. Therefore any physical disease or mental strain may be sufficient to produce insanity in women after confinement who are unstable or defective in their nervous organization; but the insanity is not the result of the disease or strain *per se,* nor is there any special form of mental aberration.

The *treatment* of puerperal insanity, therefore, is the same as the treatment of any other form of insanity. We have to accomplish, so far as possible, the elimination of untoward conditions in the environment of the patient, and at first, especially in cases of delirium or acute excitement, isolation and absolute rest in bed are essential. We cannot treat the mental condition directly, so our efforts must be directed toward the relief of such somatic disturbance as may be present. It is important to remember that no matter what the form of insanity or the previous physical condition of the patient, the presence of the mental disturbance involves also interference with the vegetative functions. Therefore the regulation of their performance becomes our first consideration. Impairment of digestion, constipation, and some renal inadequacy are always present. Therefore we should avoid, so far as possible, the administration of any drug or the use of any method of treatment which does not have in view the relief of auto-intoxication and the active stimulation of all of the emunctories of the body. It is especially important that the bowels should be thoroughly emptied and kept active. In delirium and acute excitement, much nourishment is needed; but it should be given in such form and quantity as will least tax the digestive organs. Sleep is also of the greatest importance, but it must not be gained by artificial means and at the expense of the functional activity of the vegetative organs; nor by means so powerful as to destroy the vitality of the already weakened nervous system or further depress the weakened heart. The régime to be carried out in any given case will of necessity depend upon the individuality of the patient and her environment. *Harry Ashton Tomlinson.*

XXIV. INSANITY, THYREOGENIC.—

A. Myxœdematous Insanity.

Myxœdema, first described by Gull in 1873, and named from its most superficially characteristic symptom by Ord in 1877, is due to a partial or complete loss of function of the thyroid gland,—either from congenital absence or loss in early childhood (sporadic cretinism), cystic degeneration with atrophy (endemic cretinism of goitrous subjects), parenchymatous degeneration with interstitial change (ordinary acquired myxœdema), or a surgical operation (cachexia strumipriva). The symptoms of this disorder of nutrition vary with the rapidity of loss of gland function, and also with the age of the individual at the time of onset, and there are many intermediate forms between the infantile and the adult.

Acquired myxœdema of the adult, a disease of cold climates, more common in women, is of insidious onset and usually of slow progress, with remissions during warm weather or during pregnancy, and, if untreated, terminates in death in from one to thirty years. The average duration of life is between six and seven years.

Advanced cases uniformly present mental symptoms, and there may be some question of the necessity of giving them separate consideration under the title of myxœdematous insanity, since they are merely symptoms, some constant and others occasional, which come late in the course of the disease, indicating more profound changes, and which do not appear at all if early and proper treatment is given.

These patients are slow of comprehension, of thought, and of action, exhibiting a clumsiness of mind analogous to that of their bodies. There is a feeling of lassitude, a loss of power of voluntary attention, and a distinct sense of effort in doing the little they succeed in accomplishing, even in forming the words they speak. They are dull, heavy, placid, self-satisfied, or mildly euphoric, which state in some cases is so pronounced as to have led to a diagnosis of general paralysis. Though usually mild and even-tempered, and at times stupid, perhaps sleeping eighteen hours out of the twenty-four, they are liable to be irritated by slight causes and to become confused under unusual or agitating circumstances. There is impairment of the memory for recent events from an early stage of the disease. These symptoms, which are common in a greater or less degree to all cases, may be so pronounced as to simulate dementia; but until a late stage they always have a fairly good insight into their condition, concerning which they are usually quite sensi-

tive, and sufficient stimulus elicits a much more normal response than would be expected from the appearance of the patient. At last dulness and apathy become so pronounced that they cease to appreciate or care for their condition, show little or no emotion, are unable to make any exertion, and become practically helpless.

In addition to these symptoms, which are fundamental and underlie all other mental states exhibited by these patients, a large proportion develop delusions of persecution. Sensitive about their personal appearance, they are liable to seclude themselves, which way of living in time reacts unhealthfully upon them; conscious of their good intentions, and the effort required on their part to meet the ordinary demands of life, they feel themselves misjudged by their family and friends, who, at first not recognizing disease, may think them inefficient from indolence, and they at last become suspicious of the good intentions of others toward them.

Other important elements in the development of delusions are a profound anæmia, impairment of the special senses, hallucinations and illusions which may in part result therefrom, and various subjective sensations such as headaches, noises in the ears, vertigo, pricking and tingling, numbness, etc., which are often misinterpreted as evidence of attempts by some one to injure them. These delusions are more or less firmly held, but may be merely temporary and troublesome only at night, when the patients are not always well oriented in their relations to those about them, whose attitude toward them they misunderstand and whose identity they often mistake.

The various paræsthesiæ, impairments, hallucinations and illusions of the special senses, delusions of persecution, and partial disorientation as to persons are the most common of the more transitory symptoms. A smaller proportion of cases are depressed in spirits. This depression arises in part perhaps from an appreciation of their condition and is sometimes accompanied by anxiety, all sorts of worries, apprehension, fears, self-depreciation, and a tendency to suicide. While in this state they may be sleepless and show marked restlessness and agitation with moaning, senseless resistance, and refusal of food. In others the euphoria which is so constant a symptom appears to be exaggerated, and there result short periods of mild exhilaration. If more pronounced they amount to excitement, and are often accompanied by confusion, various hallucinations, and delusions. These acute attacks are always preceded by the less obtrusive but more characteristic symptoms, and after the subsidence of the depression or excitement the more essential symptoms remain. These emotional states are no more characteristic of myxœdematous insanity than of other psychoses, in many of which they occur, and instead of aiding the diagnosis they serve to obscure the picture. It is interesting to note, in passing, that with a definite etiology, a single underlying cause, the same patient at different times may show such variety in emotional tone. This, however, is true of other psychoses.

While the character of the mental symptoms above mentioned would lead one to suspect their origin, the pre-existence and coexistence of other symptoms of myxœdema are necessary for an absolute diagnosis.

The signs of an advanced case are unmistakable. There is a deposition of mucin in the subcutaneous tissue, causing a swelling resembling ordinary œdema, but which does not pit on pressure. There is an increase in weight and a characteristic change in the appearance of the patients who at first seem to their relatives to be growing stout in an ordinary way, perhaps to the physician to have renal disease. This solid œdema appears at first in the face or ankles, and in time becomes general, although there are instances of localized myxœdematous swellings. The hands and feet become large and clumsy, being stiff and sometimes numb. Movements are slow and difficult, being limited by swelling at the joints; the gait is ponderous and unsteady, and the patient sometimes falls. The eyelids are puffy and pendulous, the brows are elevated to correct the drooping of the lids, the nose is broad, and the lips are thick. The skin of the face is yellowish and translucent, especially of the eyelids, and there is often a red spot on either cheek. The face shows little change of expression to emotion. The skin generally is downless, dry, scaly, non-perspiring, and has a tendency to crack. The nails are brittle, the hair becomes dry and finally thin all over the body, perhaps disappearing in places. The teeth are carious, the breath is foul, the tongue, soft palate and gums are pale in color, swollen, and there is often a discharge of bloody mucus from the mouth, and a tendency to the formation of polypi and hemorrhoids, and to hemorrhages from the mucous membranes generally. The voice is husky; speech is deliberate and monotonous. The special senses are often impaired, though this varies with the condition of the patient, since sometimes they see and hear with difficulty and again perfectly. Sensation varies from an almost normal condition to marked anæsthesia and analgesia. Conduction of sensation appears to be slow, although it is difficult to determine how much of the slowness is due to the mental condition. The eyes water in cold weather, especially in a wind. The body-temperature may be subnormal. These patients are very sensitive to cold, wearing an abundance of heavy clothing, and living in warm rooms. The bodily condition is one of anæmia,—the percentage of hæmoglobin is reduced, there is a moderate leucocytosis. The heart is often enlarged, the beat slow and weak, while the rate is markedly increased by moderate exercise. The urine is diminished in quantity (500 to 700 c.c.), in specific gravity, and in total amount of urea excreted; and in a case of long standing it often contains a trace of albumin and casts. These advanced cases also show watery œdema due to the renal change. They have attacks of palpitation and dyspnœa, and sometimes short periods of unconsciousness or epileptiform seizures. The slow onset, the frequent sense of well-being and occasional delusions of grandeur, the mental stupidity simulating dementia, the peculiar speech, the clumsy gait, the general inability to make precise movements, and the attacks of unconsciousness might suggest general paralysis, but the presence of other symptoms of myxœdema, notably the solid œdema, should prevent this mistake.

The *treatment* is that for myxœdema. It consists in supplying the deficiency of something necessary to normal metabolism by the cautious administration of the desiccated thyroid of the sheep. It is expedient to give smaller doses and for a longer period of time than was formerly the practice in order to avoid certain unpleasant and even dangerous effects. The symptoms of overdose are anorexia, coated tongue, foul breath, nausea, vomiting, and diarrhœa; headaches, pains in the limbs and in the chest, simulating angina; a moderate rise of temperature, restlessness, mental irritability or even excitement; a reduction in the percentage of hæmoglobin, an increased leucocytosis; a rapid pulse especially on exertion, vertigo, palpitation, dyspnœa, and syncope. Especial care is to be taken in cases of mental excitement with a tendency to exhaustion, and in those with great anæmia and a weak heart. It is well to remember that the effects of the remedy on cases of myxœdema are more pronounced than on healthy people, that it is better borne by the young than by those in whom atheromatous changes have begun, that it is said to light up a latent tuberculosis, that deaths in syncope have been reported following very moderate exertion, and that it is cumulative in its effects, the danger existing for some time after cessation of administration. It is interesting to note that from large doses symptoms are developed, the antithesis of those characteristic of myxœdema, viz.: tachycardia, restlessness, irritability or mental excitement,—in other words the mental state of exophthalmic goitre.

During active treatment the patient should be kept in bed to avoid exertion, which is dangerous; massage should be given to aid elimination of mucin, and an iron tonic administered to correct the anæmia already existing and to prevent an additional reduction of hæmoglobin. One should begin with gr. i. or ij. doses of desiccated thyroids (equivalent to gr. iiss. to v. of the fresh gland)

twice daily. The remedy causes at first an increase in the quantity of urine and of the urea eliminated. When the patient is in a normal condition so far as the myxœdema is concerned the dose which will maintain this state must be determined and taken regularly throughout the life of the individual. The quantity varies with the person and season, a larger dose being required in winter, but usually gr. ss. to i. daily, perhaps each second day, is sufficient. Notwithstanding the brilliant results of treatment it is a question if these patients are not left with some slight mental defect.

B. Cretinism.*

Cretinism, or myxœdema in the child, presents a variation of symptoms according to the age at the time of onset, the rapidity and the completeness of the loss of function of the thyroid. The gland may not have developed, in which case the child shows marked symptoms at birth and dies; an atrophy may have begun before birth, the child at that time showing symptoms, but the disease may progress slowly and life may be prolonged for years; or the condition may be normal at birth and the disease appear early, usually before the fifth year. In this latter class are included most of the sporadic cases. The endemic form, usually with goitre, may begin to show symptoms at any age. When the gland is congenitally absent or the loss of function progresses rapidly, the child dies early. If the atrophy or degeneration begins later in childhood or in adolescence, and especially if it proceeds slowly, there is the usual arrest of development of body and mind, but the individual may live to the age of forty years or more.

The mental state varies, according to the bodily condition, from an amentia of the congenital form to a slight degree of enfeeblement in the cretinoid state; but allowing for modification because of infantile lack of development there is a striking similarity between the mental symptoms which manifest themselves in a case in which the disease began in childhood and those which are observed in one of later development—viz., in adult life.† Cretins have a marked psychomotor retardation,—they are exceedingly slow in their mental operations and in their movements. They lack the interest, the inquisitiveness, of normal children, have little power of attention and will sit for hours without noticing their surroundings. Because of their lack of ability normally to receive impressions, to remember, to form ideas, and to reason to conclusions, they gain little experience and remain children in mind as well as in body throughout their lives. Only the most intelligent are capable of any occupation. Many do not learn to talk or even to communicate by signs, are filthy in their habits, cannot walk or stand without assistance, and have an inordinate appetite with apparent absence of the sense of taste. They show slight capacity for exertion; some are entirely helpless. This torpor is due partly to the mental condition and partly to muscular weakness.

They show little emotion, are placid or stupid, often sleeping more than healthy children, but while they are dependent, shy, affectionate, mild, and even-tempered, if annoyed they may be for short periods of time sulky, obstinate, irritable, or they may exhibit violent fits of temper.

The special senses are often imperfect, particularly those of hearing and smell, though it is difficult to ascertain this because of the stupid condition of the patient. Cutaneous sensation is usually diminished. The deep reflexes are active.

Less frequently than in myxœdema of the adult a few of the more intelligent develop delusions; they are also liable to periods of depression and excitement. These mental states are not characteristic of cretinism, they are no doubt due largely to the intense anæmia, to various perversions of ordinary sensation, and to the imperfection of the special senses.

* See *Goitre and Cretinism*.

† See "Myxœdematous Insanity," in the first section of this article.

While the mental condition is quite characteristic it is even more true than in the adult form that the diagnosis of cretinism must be made chiefly from physical signs. The dwarfed stature, perhaps not over three feet at the age of twenty-one years, and the childish appearance; the solid œdema which is most conspicuous in the face, hands, and feet; the broad head with the anterior fontanel still open; the eyes apparently far apart and partially covered by swollen lids; the broad, flat nose; the large mouth with thick lips, large, protruding tongue, and carious teeth; the lack of intelligence in the face, the skin of which is sallow and waxy in appearance; the rough, dry skin over the body generally, on which the hair is coarse and thin, or wholly absent; the short, thick neck with swellings above the clavicle; the prominent abdomen, perhaps with herniæ; the poorly developed, crooked limbs; the slow, awkward gait, if the patient is able to walk; the lack of sexual development; the harsh or shrill voice; a subnormal temperature, great sensitiveness to cold, a slow pulse and respiration—all make a picture not easily mistaken. In making the diagnosis cases should be excluded which do not show the most characteristic signs of myxœdema, viz., the solid œdema, and the changes in the skin and its appendages.

The *treatment* is that for myxœdema beginning at any age, and, although children bear proportionately larger doses than the adult, death has occurred and desiccated thyroid should be administered with care.* The patient should be kept in bed, or exercise should be greatly limited, during the stage of most active treatment, not only because of the slight danger of syncope, but also to avoid the bending of the bones of the legs which then grow rapidly. Splints are sometimes applied.

The effect of treatment is immediate and most pronounced in removing the physical signs of myxœdema. A change in the mental condition is not so prompt, but in a general way it may be said to keep pace with the subsequent bodily growth. The removal of the myxœdematous swelling, the softening of the skin, the growth of hair and of teeth make a striking change in the appearance of the patient; at the same time there is more activity of body and mind; the characteristic torpor disappears; the power of attention increases, and the child begins to gain experience. Notwithstanding the wonderful improvement which is quickly made by removal of the physical signs, there still remains, in the cretin who has passed the period of puberty without treatment, an undeveloped mind in a stunted body. The amount of development that can be expected in any case depends on the capacity of the individual for growth, which varies inversely with the age. Hence the importance of an early diagnosis. With sufficiently early and judicious treatment there is no reason why a cretin should not develop into a normal individual. When treatment is delayed several years, or till after puberty, improvement only can be attained. As in all cases of myxœdema the patient must take regularly throughout life a sufficient amount of desiccated thyroid to prevent a recurrence of symptoms. *George T. Tuttle.*

XXV. INSANITY FROM ARREST OF DEVELOPMENT: IDIOCY, IMBECILITY.—Idiocy, imbecility, and feeble-mindedness are varying grades of the same condition. They represent checked cerebral development. As such they cannot, strictly, be classed with the insanities since insanity indicates a perversion of function of cerebral structures which are present. In idiocy, these structures have never fully developed or have remained altogether absent. Idiocy, therefore, implies defect, while insanity implies perversion. Before the age of puberty, true insanity is rare. It is true that general paresis has been reported in children of twelve; that paranoia may begin to show itself, as shyness, suspiciousness, and egoism still earlier, and be fairly well developed by fourteen or even younger. Similarly, mania and melancholia are reported as having occurred in children. In the larger number of

* For symptoms of overdose see "Myxœdematous Insanity."

cases such mental disturbances are the developments or manifestations of idiocy and imbecility. They are usually severe and brief. After them, the mental clouding seems deeper.

The brain of the child does not attain its full structural development until the fifteenth year of life. Consequently the pathology of idiocy is no less a chapter than the pathology of the brain in infancy and childhood; and among the causes of idiocy must be reckoned all injurious influences which act upon the brain before the fifteenth year. Mental defect resulting from injuries to brain structure after that period is dementia. There has been a somewhat reactionary tendency in the interest centring about idiocy. Thirty or forty years ago, the investigators of this subject were chiefly pathologists and comparative anatomists. To-day the trend of study is clinical, psychological, and pedagogical. The causes, the early recognition, and above all the education of backward children are now the chief objects of inquiry. The present article only essays to give a sketch of the whole subject. For more detailed descriptions the reader is referred to the special literature, which is voluminous.

FIG. 2845.—Case of Sporadic Cretinism, Dwarfism. Patient aged twenty-two years; height, forty and one-half inches; weight, fifty-seven pounds. (From collection of Walter E. Fernald.)

PATHOLOGY.—The lesions in idiocy are gross and microscopic. The gross lesions consist of tumors, areas of sclerosis, meningeal thickenings, and of defects and malformations. Thus the cortical convolutions are absent or imperfectly developed; or the basal ganglia are absent; the corpus callosum is sometimes totally deficient, as are also both lobes of the cerebellum. These defects may be the results of agenesis, or they may have been caused by intracranial hemorrhage. In the latter event, large cysts are often present. Forencephaly and hypertrophy and true microcephaly of the brain are comparatively rare conditions. Hydrocephalus, on the other hand, is common. It may exist as an independent lesion or may complicate any of the others. Contrasted with these gross defects are those in which the brain as a whole is within normal limits as to architecture and size, but in which microscopical examination shows defects in the ganglion cells of the cortex. The cells are fewer in number and imperfectly developed. In general, the greater the gross anatomical defect, the greater is the intellectual failure. This rule is not absolute, however. Cases are on record in which gross lesions were associated with considerable intelligence. On the other hand, some profound idiots have brains of fairly normal outlines.

ETIOLOGY.—The causes of idiocy, imbecility, and feeble-mindedness may best be considered as they occur before, at, and after birth. The prenatal causes are the most important. In over fifty per cent. of feeble-minded children the cause can be shown to be congenital. In most, the causes are directly traceable to defective nervous systems on the part of the forebears. From families with distinct neurotic taint, viz., the insane, the epileptic, the alcoholic, hysterical, and the like, idiotic or feeble-minded children are pretty sure to issue. The chances are greater in consanguineous marriages when neither side of the family has a clear record. They are especially great when feeble-mindedness is a parental stigma. Direct inheritance, with perpetuation of type, is more frequent in idiocy than in any other degenerative condition. This question is of extreme practical importance, as feeble-minded women are easy prey to the lusts of men, and when lacking proper protectors are a menace to the state through increasing its dependents. Alcohol stands in prominent relationship to idiocy and feeble-mindedness. Of 2,554 admissions to the Bicêtre for idiocy, imbecility, epilepsy, and hysteria, in forty-five per cent. one or both parents drank to excess (Bourneville, "Recherches," etc., Paris, 1901). Active syphilis and tuberculosis in the parents, aside from giving rise to gross lesions, may also be responsible for failure in development. The other prenatal causes of idiocy and feeble-mindedness are related to diseases and injuries affecting the mother during the period of her pregnancy. The causes acting at birth are chiefly traumatic. During or just preceding delivery, the child's brain sustains injury. First children and boys are chiefly exposed to such dangers. Into the rubric of causes acting after birth all pathogenic agencies, traumatic, toxic, or nutritional, fall. In considering these causes, it must be borne in mind that the brain of the infant and child is an extremely delicate organ, undergoing rapid development. At the end of the second year it weighs three times as much as it did at birth. In the essentially reflex character of its function and in its quick response to stimuli, it resembles a primitive nervous ganglion more than it does the adult encephalon. Apparently trivial causes may therefore arrest its development; and any arrest, in so rapidly growing an organ, may have far-reaching results. It differs in another respect from the adult brain in that focal diseases affect the whole brain. Thus the chief symptom of cerebral tumors in infants is stupidity, whereas in adults they may cause no mental symptoms. It is thus readily apparent that the younger the child the greater is the chance of a brain affection having far-reaching effects on the intelligence. Of the most important causes acting in infancy and early childhood may be mentioned: cerebral and meningeal hemorrhage; meningitis, especially the cerebro-spinal form; the infectious diseases, notably scarlet fever and typhoid fever; and convulsions from any cause, but particularly the convulsions of epilepsy. Malnutrition is doubtless a cause of feeble-mindedness and idiocy, as is also rickets. General malnutrition is also possibly responsible for amaurotic family idiocy. Cretinism illustrates the importance of the internal secretions for brain development. Of external poisons, alcohol, and possibly some drugs given for therapeutic purposes, have checked mental development. Trauma is regularly mentioned as a cause, but it is rarely possible satisfactorily to prove such a relation. The loss of one or more of the special senses as causes will be mentioned under sensorial idiocy.

Symptoms.—The symptoms of mental arrest naturally vary with the time when the arrest occurs, and in some ways with the causes of it. In congenital cases the child is usually several months old before the mother notices that it is different from other children. In acquired cases, such, for example, as those caused by meningitis, the mental arrest is noticed consecutively to the cause. Between profound idiots, whose life is purely automatic and vegetative, and feeble-minded or backward children, there is too wide a gap to permit a satisfactory description of symptoms which shall hold good for both classes. Consequently I shall first give a description of the symptoms of the profounder grades of mental arrest, and later shall describe the symptoms as they are observed in children who are feeble-minded or backward. Between these two extremes will be found many cases, some of which incline to one end of the scale, others to the other.

Symptoms of Profound Idiocy.—These are physical and mental. The physical symptoms due to paralysis, etc., will be described under Diagnosis as to Clinical Type. Of other physical symptoms cranial anomalies are the most constant. The skull is too large or too small or asymmetrical. The nose and ears frequently have degenerative stigmata. The lips are thick and the teeth defective. In short, it is profound idiots that give the best opportunity for the study of the anatomical stigmata of degeneration. Nearly all the patients are undersized, ill-proportioned, and clumsy. All are homely and most are repulsive in appearance. The mental state of profound idiots shuts them off completely from society and makes them automata or worse. They talk, either not at all or indistinctly; they lie in bed motionless, or performing rhythmical movements and uttering meaningless sounds; the saliva runs from the mouth; the urine and fæces are passed involuntarily; their attention can be attracted either very imperfectly or not at all by sights and sounds. The pain sense is greatly diminished. The severe wounds and mutilations which idiots are apt to receive accidentally often pass uncomplained of. Also in pneumonia, to which they are very liable, they give no evidence of pain. Such are the main characteristics of profound idiots. By reason of them the patients are entirely helpless, requiring to be fed and cared for in every way. In idiocy of less degree, but in which the mental defects are still profound, some of the above symptoms are less pronounced or altogether wanting. Thus some can talk fairly intelligibly. Many hopeless idiots are not bedridden, and care for their persons to a certain extent. Some run about, laughing and chattering to themselves, looking and acting like large-sized monkeys. They understand much of what is said to them and can be made subservient to a certain degree of discipline.

Symptoms of Feeble-mindedness.—Such patients as correspond to the description just given are usually the inmates of asylums and homes, or, if they are kept at home, are rarely or never seen by visitors. They are pariahs and are susceptible of little or no improvement. In strong contrast to them are the children who are backward and mentally deficient, but not profoundly idiotic. This latter class is a large one, and in it pedagogical efforts have been crowned with no little success. A fairly typical history in a case from this class is as follows. Some of the degenerative stigmata are present in the parents, or there was a difficult labor when the child was born, or severe convulsions occurred in childhood. At birth the baby seemed normal, took its nourishment well and increased in weight. The mother may have noticed about the sixth or eighth month that the baby was less playful than other babies, that it did not follow objects with its eyes, that its attention was difficult to attract. Failing to notice these things, she may have allowed the child to pass its second year without learning to say any words. In some cases slowness in learning to walk is the first thing to attract parental attention. This symptom is of less value than are some of the others, as there is considerable physiological variation in the age at which children learn to walk, and also because deficient children often learn to walk early. In other cases the child passes through the period of infancy without being remarked as noticeably backward, and it is not until the school teacher reports slow progress and a mental calibre inferior to its age, that it is finally brought to the physician for advice. In other cases the mental deficiency is established in direct sequence to an infectious disease, and comes as an abrupt interruption of previously normal progress. In such cases the child may lose much of the intelligence it had gained. When the little patient is finally brought under the observation of the physician, some or all of the following symptoms are referred to by the parents. In all grades of feeble-mindedness, and at all ages, the fundamental defect noticed is lack of attention. In young children this is shown by their failing to be attracted by sights and sounds at an age when they should be so attracted; in older children, by the inability to keep their minds on their work. Even in play they fall behind the others by failure of attention. Some imbeciles, while failing in attention in most matters, can give good attention to others. This is especially shown in mischievous acts. Consecutive thinking and reflection are not compatible with great feeble-mindedness. In mild grades of feeble-mindedness the instincts are not greatly different from what they are in health. Hunger is felt by all, and is often indulged to the point of gluttony. As genius is independence and originality, so feeble-mindedness, which is far removed from genius, is the other extreme. Thus the imitative instinct is strongly developed in the feeble-minded. Some feeble-minded children are docile and polite, but a larger number are rude and uncivil and are often difficult to train in this direction. Destructiveness, a special attribute of infancy, is continued in idiocy and feeble-mindedness beyond the age at which normal children learn the value of property and the rights of others. Profound idiots are destructive at all times. In lesser grades this tendency may appear only during fits of anger. Again, it may appear as an impulse coming without apparent cause, like the impulses in some forms of chronic degenerative insanity. Imbeciles and the feeble-minded are thus sometimes incited to dangerous and unprovoked assaults or to the setting fire to buildings. As a rule the patients are timid in the extreme, but in their fits of excitement and anger they lose all appreciation of consequences and seem fearless. At such times they are probably irresponsible and may be very dangerous. They attempt, under such circumstances, to do injury to anything in their vicinity, animate or inanimate, and are very difficult to restrain. An excited imbecile is usually a very dangerous person. The feeble-minded are acutely sensitive to pleasure and pain. As a rule, also, they are affectionate, although their affection does not reach the plane of self-sacrifice. All appreciate kindness and are repelled by rough treatment. Most feeble-minded children are mischievous. They are usually untruthful, and will often steal. As regards the higher intellectual faculties, there is naturally a great variation in the feeble-minded. In the milder grades all these faculties are present, though generally less acute than in normal people. As a rule judgment, will, memory, and self-control are all impaired. In some, however, the judgment in regard to simple matters is good; the will may be well developed though it manifests itself as stubbornness rather than as tenacity of reasonable purpose. In certain cases the memory is developed to an extraordinary degree. Credulity and instability of the emotions are common characteristics of a weak intellect generally. Manifestations of these traits are seen even, in adults who pass as normal, in the following of fads, faith cures, and bizarre creeds. The vast majority of the followers of such movements are distinctly feeble-minded. In profound idiocy, of course, credulity cannot enter. But in the unequal intellectual development of feeble-minded children, credulity and instability of the emotions are prominent features. Such children delight and believe in fairy stories, or are terrorized by ghost stories, beyond the usual age when such fictions cease to interest. Sleep is usually impaired. Masturbation is common.

The disposition of feeble-minded children is subject

to wide variations, as has been indicated above. Some are docile, quiet, affectionate little creatures, very timid, incapable of harming others, but capable of running away or even of committing suicide if harshly censured. Others are the direct antithesis to this. Moody and sullen; they exhibit little affection for those around them. They fly into violent passions, either when, at home, they are not given their own way, or in their play with other children. When aroused, they are often very violent, destroying anything they can lay their hands on, attacking those near them, biting, scratching, or hurling loose objects, with total disregard to consequences. Representatives of this latter class are naturally very hard to educate. All require more or less supervision and some are entirely incapable of taking any care of themselves.

Speech, with its correlates—the ability to read and to write—is present in feeble-minded children. If speech is absent (with the exception of certain paralytic conditions and of deaf-mutism) the mental condition is worse than feeble-mindedness. Learning to speak is, however, often late in appearing and the articulation is commonly impaired. Lisping and jerking utterances are common symptoms. The vocabulary also is apt to be more limited than in normal children, though many feeble-minded children are very loquacious. The same is true with regard to reading and writing. These accomplishments can be acquired by feeble-minded children. But they are late in point of time, and imperfect, usually, in

FIG. 2846.—Idiocy with Hydrocephalus. (Fernald.)

point of development. The patients can often read, write, or draw without really understanding what they do. Desire for movement is a characteristic in all degrees of intellectual retardation. In profound idiots it is manifested in the rhythmical movements, the habit spasms, the tics, the contortions of the features. In the feeble-minded it is present either as an extreme restlessness, or as a purposeless moving to and fro. Many of these children are also afflicted with a kind of chronic chorea, consisting of involuntary twitchings of different groups of muscles. These movements are rendered more pronounced by excitement and observation.

DIAGNOSIS.—The early diagnosis of idiocy and feeble-mindedness is important chiefly from the point of view of education. It is very essential, for the attainment of practical results, that training begin early. The diagnosis as to the intellectual defect in the early months of infancy, if this defect is not profound, is practically impossible. There is so much physiological variation in normal development that slight irregularities, although they may excite the physician's suspicion, cannot be relied upon as diagnostic. The normal development of the infant at varying periods can be found in different works on child study, notably that of Preyer. When variations from a normal standard are combined with physical defects, such as paralysis, or with a bad parental or personal history, the diagnosis is easier.

The diagnosis as to cause can sometimes be made out. The questions involved have been discussed in the section on etiology. The greatest importance in causal diagnosis is the recognition of cretinism (*q. v.*). The diagnosis as to clinical type embraces the following forms, which are anatomical rather than clinical, for it can hardly be said that there is a mental defect characteristic of any one of them. Any one of them, also, may have defects of varying degrees.

Hydrocephalic Idiocy.—Hydrocephalic idiocy includes the cases in which the mental enfeeblement is due to pressure on the cortex brought about by overdistention of the ventricular cavities of the brain with fluid. It may complicate tumors, cysts, etc., or may be a sequel of meningitis. It frequently exists as an independent condition. It has been assumed that it owes its origin to closure of the foramen of Magendie, so that communication of the ventricles with the subarachnoid space is shut off. Operations undertaken with the object of artificially creating such communication have not proved successful. The most striking symptom of hydrocephalus is enlargement of the head. The degree of enlargement and the condition of the fontanels and sutures depend on the cause and the time of its operation. With closed fontanels, the increase in the size of the head is only moderate. When the distention begins before the fontanels have closed, the increase may be enormous. Under such conditions the rounded skull cap rises as a vault or dome above the small wizened face. Hydrocephalic children are generally feeble and puny, and this, in conjunction with the increased weight of the head, makes them quiet, often rendering it necessary for them to be in bed most of the time. Rachitis, paralyses, and epilepsy are frequent complications or concomitants. These little patients are as a rule quiet, serious, and only of moderate mental deficiency. They are usually vain and fond of little "old-maid" ways. In the larger number of cases they die of pneumonia or general inanition. Some live to be harmless adult imbeciles.

Microcephalic Idiocy.—In many cases of idiocy the heads are small. The term microcephalic idiocy, however, is usually reserved for the cases in which both skull and brain are uniformly diminished in size, without there being paralysis or other evidence of focal lesion to account for it. As a cause of this condition, premature closure of the sutures is sometimes advanced. The question is of importance in its surgical relations. The fact that microcephalia can occur and the sutures remain open; the absence of much valuable evidence that, in cases of closure, surgical operations are of benefit; and the general law that early closure is an evidence of a degeneration which affects the development of the brain as well as that of the skull, have all led to the general conviction that early closure, *per se*, is not sufficient to explain the condition. The low slanting forehead, the high-set eyes, and the absence of cranial vault, give a peculiar bird- or animal-like appearance to microcephalic idiots.

The resemblance to the lower animals is further enhanced by the fact that the patients are usually very much undersized (often distinctly dwarfed), and further by their general behavior. When not profoundly idiotic, microcephalics are unsually active, energetic little creatures, running about constantly, and even when sitting down going through rhythmical movements. They chatter and laugh, but few can talk coherently. They are much more robust than hydrocephalics, and some attain advanced age. They are, however, not susceptible to much improvement through education.

Paralytic Idiocy.—Under this heading are grouped the cases in which gross cerebral lesions occurring in infancy and early childhood cause paralysis of the limbs. As has already been said, focal lesions during development are particularly prone to affect the brain in its entirety. In infancy and early childhood, therefore, any intracranial accident, even though it be slight, may seriously interfere with intellectual elaboration. The infantile cerebral palsies have three chief distributions, viz., hemiplegic, diplegic, and paraplegic. They nearly always result from circulatory disturbances, such as hemorrhage, particularly from the meninges, thrombosis, and, less frequently, embolism. They may also result from intracranial inflammations and sometimes from new growths.

The hemiplegic variety constitutes a considerable proportion of all cases of idiocy. The cerebral palsies are an important chapter in pediatrics. If the palsy is prenatal, profound idiocy is almost always the result. There is also little chance that a normal mind will develop when the palsy occurs in the first few months of life. In older children, considerably more than half escape without mental defect. There is danger, however, in all such cases that epilepsy will result from the irritation of the cerebral lesion, and that mental defects will follow in the course of the epilepsy. The symptoms of hemiplegic idiocy are the symptoms of hemiplegia plus the symptoms of idiocy or feeble-mindedness. These latter are, as a rule, less constant and less pronounced than in other paralytic forms. Of 55 cases examined by Sachs and Peterson, the mental impairment was classified as feeble-mindedness in 16, imbecility in 31, idiocy in 7, and epileptic insanity in 1. The physical symptoms—namely, those of hemiplegia—have some peculiarities which distinguish it from that of adults. Thus there is almost always some flattening of the skull on the side of the brain lesion, the horizontal hemicircumference of the head being less on the affected side. There is apt to be shortening of the limbs on the paralyzed side, and the rigidity and contractures are frequently extreme. All these symptoms vary with the extent of the paralysis, which may be severe and extensive, or only slight. In the latter case it is likely to pass away, leaving only a slight rigidity, or an increased tendon reflex, or athetoid movements, on the affected side. Epilepsy, however, may complicate this condition, even when the initial paralysis has been slight and its late effects insignificant. (See Plate C.)

In diplegic idiocy the paralysis involves all four extremities. It is almost always congenital or is first observed shortly after delivery. The most plausible explanation of its occurrence is that during delivery the head is injured so that blood is extravasated in the great longitudinal fissure of the brain. The paralysis in these cases is usually extreme and the muscular rigidity severe and disabling. On account of the spasm of the adductors the thighs are drawn one over the other; the patients are thus totally disabled from walking, or else they can do so very imperfectly, making the "crossed-leg progression." The hands are also often much incapacitated. The percentage of mental defects in these patients is high (over seventy per cent.) and the degree of the defect is usually extreme.

Paraplegic idiocy probably originates in the same way as the diplegic variety, but the upper extremities escape. These cases were long misunderstood, as the paraplegic type suggested a spinal lesion. The lesion is, however, cerebral, and probably is due to hemorrhage which either did not affect the centres for the upper extremities or else affected them so slightly that nearly perfect restitution occurred. What has been said regarding the clinical aspects of diplegic idiocy holds good for the paraplegic form.

Epileptic Idiocy.—As the mental defects resulting from epilepsy are often of secondary importance to the epilepsy itself, this section might be better handled in the article on epilepsy. But epilepsy is too important a cause of idiocy and feeble-mindedness to be altogether neglected here. It is a very common disease of infancy and childhood, and under the most favorable circumstances of environment and treatment, a large proportion of its victims undergo mental arrest or enfeeblement. Of the selected cases which are admitted to Craig Colony for Epileptics at Sonyea, about twenty per cent. become demented. Epilepsy stands in a causal relation to feeble-mindedness in two chief ways. First, both the convulsive phenomena and the stoppage of the intellectual growth may result from a common organic cause. Examples of such a cause are the various cerebral palsies, tumors, cysts, meningitic sequelæ, hydrocephalus, etc. Under such circumstances the epilepsy may not appear for months or years after the mental trouble has developed. In some cases the epilepsy develops first, so that it seems as though the attacks themselves brought about the feeble-mindedness, rather than the gross intracranial lesion. Idiopathic epilepsy is also fertile in checking intellectual progress. In this variety of the disease there are no gross cerebral changes sufficient to explain it. In a large proportion of cases bad heredity is demonstrable. But also the number of cases of idiopathic epilepsy, in which no cause whatever is demonstrable, is not small. Whatever the origin, feeble-mindedness and epilepsy together render the prognosis

FIG. 2847.—Imbecility with Spastic Diplegia following Injury by Forceps at Birth; showing Choreiform Movements, Muscular Incoordination, Athetosis. Patient aged twenty-five years. (Fernald.)

almost hopeless. The tendency of this combination is progressively downward.

Traumatic Idiocy.—In the history given by mothers and other members of the family, trauma is constantly advanced as a cause of mental defect. Clinically, however, traumatic idiocy has no distinguishing features, and in view of the fact that few children grow up without falls and bruises, one has to be extremely conservative about accepting injury as a cause.

FIG. 2848.—Idiocy with Spastic Diplegia; showing Adduction of Muscles of the Thigh, Talipes, General Muscular Incoordination, Choreiform Movements, etc. Patient aged twenty-six years. (Fernald.)

Sensorial Idiocy.—This class includes the mental defects observed in children who have lost one or more of the special senses, especially sight or hearing. There are certain remarkable instances in which, after loss of sight and hearing with its attendant mutism, the patients have developed into persons of excellent intelligence. They naturally never attained intellectual conceptions which these senses alone can furnish. But otherwise they have been intellectually normal. Such results are, however, unusual. As a general rule, children who are shut off from these avenues of education do not attain full intellectual development.

Amaurotic Family Idiocy.—This is a very rare condition, occurring chiefly in Hebrew children between the second and eighth months of life. There is degeneration throughout the whole cerebro-spinal nervous system, of which the clinical evidences are paralysis, impairment of sight or blindness, and mental defect. The ophthalmoscope shows characteristic changes in the neighborhood of the macula, originally described as "a white speck more or less circular, in the centre of which is a brown point, offering a sharp contrast to the white." Optic atrophy occurs eventually. The children rarely survive the second year.

Backward Children.—In addition to the various classes of defective mental development which have now been described, a word must be said in regard to children who are not idiotic, who in fact can hardly be called feebleminded, yet who are backward. All such children merit the most painstaking psychological and physical examination. In many cases the principal defect seems to be a failure of attention, without there being any demonstrable physical cause. We must then assume that somewhere in the course of personal or ancestral development checks were given to progress, and that the child is intellectually below par because he lacks functionally capable ganglion cells. Under such circumstances the most that treatment can do is to enhance the function of existing cells; it cannot, of course, furnish new ones. But in other cases brain cells may be normal in structure and potentially normal in function, and the reason why they fail to give evidence of normal action is to be found in temporary conditions, which are susceptible of removal with the cure of the patient. Among such temporary conditions are visual disturbances, especially errors in refraction, disturbances of hearing, general diseases and malnutrition, and possibly obstructive disease of the nasopharynx. Interferences with sight and hearing are the most important of these, owing to the fact that they are so often overlooked. Many children are catalogued as backward, whereas the whole trouble depends on their being unable to see or hear well. Oftentimes defective

FIG. 2849.—Spastic Paraplegia, Idiocy, and Defective Development of Cranium. Patient aged four years; height, thirty-two inches; weight, sixteen pounds; circumference of cranium, sixteen and one-sixth inches. (Fernald.)

FIG. 1.—Group of Cases of Idiocy. (Fernald.)

FIG. 2.—Group of Feeble-Minded Boys of the Higher Grade, Capable of some Scholastic Development. Cases of this type may learn to read, write, etc. (Fernald.)

vision is discovered by it being noticed that the child is slow in learning to read, or that it is a bad speller. Partial deafness closely simulates failure of attention. Whether interference with the breathing, dependent upon some naso-pharyngeal disease, causes the appearance of feeble-mindedness, or not, seems to me doubtful. It is so maintained, however, by some authorities. General diseases require little comment. But stress must be laid on the condition of over-fatigue, into which many children are pushed by the excessive work they are forced to do. It is by no means a rare experience with me for mothers to bring children, between the ages of eight and twelve or fourteen, to be examined because the school teacher has reported slow progress and backwardness. Examination shows the children to be of good intelligence, and not very much under a normal standard of health. But there is a general appearance about them of fatigue; in sitting, they do not hold themselves erect; in standing, they attempt to help support the weight of the body by leaning against the wall or by laying the hands on the desk or table. Inquiry as to daily routine shows that the children are doing very much more work than they should, and that their hours of unregulated and untrammelled play are too short. The following is the routine which a child of fourteen was expected to follow in a large girl's school in New York. Rising at 6:15 A.M., she was kept constantly busy with school duties until 10:30. A recess of fifteen minutes was followed by more recitations and study till the half-hour dinner at 12. Play was allowed immediately after dinner, for an hour, then followed practising, sewing, recitations, study, religious exercises until 6:30, with a recess of only fifteen minutes. After supper the only free time was from 7:30 to 8:15 when bedtime came. Thus, of the whole twenty-four hours, only one, and that one directly after the heartiest meal, was given over to uninterrupted play. Is it remarkable, under such circumstances, that a child gives irrelevant answers to questions, that he cannot remember well, that his lessons are imperfectly learned, that he is irritable and fretful?

PROGNOSIS.—The prognosis of idiocy concerns life and intellectual prospects. In a large number of the congenital or early developed cases death occurs in the first few months or years of life. These patients are particularly subject to such diseases as diarrhœa and pneumonia. From all points of view the defective and feeble-minded are poorly equipped for the struggle for existence and die prematurely. Most idiots who survive infancy, die before twenty, few live to be over forty. Occasionally, however, cases are met with that live to old age. The prognosis as to life must, with few exceptions, be made to depend upon the degree of malnutrition which may be present; generally the latter is directly proportionate to the degree of mental defect.

The prognosis as regards the intellectual condition has reference solely to the question of improvement. There is no such thing as a cure in arrested mental development. If the child is not teachable, even improvement is out of the question, except possibly in cretinism. If, on the other hand, the child can be taught, much can be attained by modern pedagogical methods. The statistics contained in the twenty-seventh annual report of the Royal Albert Asylum at Lancaster, England, showed, with regard to the after-career of pupils discharged on completion of their seven years' training, that ten per cent. were or had been earning wages; that five per cent. were remuneratively employed at home; and that three and one-half per cent. additional were capable of earning wages. Such favorable results can be expected in a small proportion of cases only. In the others we have to be satisfied if the patient learns to talk, to acquire a knowledge of some simple kind of handiwork and habits of cleanliness, to show respect for authority, and to exercise some measure of self-restraint. The prognosis varies also with the degree of original defect and with the age at which training is begun. The latter should not be delayed beyond the third or fourth year, and should be begun earlier if possible.

TREATMENT.—The treatment of idiocy is medical, surgical, and pedagogical.

The medical treatment is not different from the medical treatment of children generally. The physician is, however, more largely thrown on his own resources. Statements from the patients are either not forthcoming or are unreliable; and the absence or diminution of the pain sense cuts out the diagnostic symptom of pain.

Surgical procedures, directed toward relief of the mental state, are rarely if ever justifiable. Tapping the lateral ventricles in hydrocephalus, and trephining in microcephalics, on the theory of premature ossification of the skull, are tried from time to time. But it is a matter of considerable doubt if these procedures do any real good.

The object of pedagogical measures is to increase the acuity of the senses, to teach coördinated use of the muscles, to instil good habits and eradicate bad ones, to teach the use of language, to inculcate ideas of form, number, length, weight, surface solids, and, finally, to apply these results to still higher education. The sense of touch is educated by surfaces of varying degrees of smoothness, by soft and hard objects, by stringing beads, by buttoning specially made buttons, etc. The eye is educated by yarns of different colors, by blocks, cubes and balls of different colors and sizes, by various mechanical games, etc. Gongs, bells, music, singing, etc., help to educate the ear. By the improvement in the acuity of these senses, there naturally results an increase in attention and a better coördination of movement. Walking is taught by increasing the strength of the legs by massage and passive movements, and then by various mechanical devices. By analogous means, the hands are accustomed to coördinated movements. The key to teaching habits of cleanliness of the person, etc., is to be found in the watchfulness and assiduity of the nurse, and, above all, in the absolute *regularity* with which the various procedures are carried out. Certain bad habits must be grappled with. Constant watchfulness is the only cure for masturbation, which is a very difficult symptom to overcome. It is sometimes necessary to tie the patients at night. Sucking the fingers and biting the nails are cured by the application of a solution of aloes or other disagreeable substance.

Speech is taught by the oral method, or by constant and regular exercise in speaking correctly. Manual training and industrial training follow naturally after simpler things have been learned. (See Plate C.)

Further into the details of the pedagogical methods currently used in idiocy it is impossible to enter here. It is the province of the psychologist and educator, rather than of the physician. But in closing it may be said that the earlier such treatment is begun the better, and that better results are generally obtained in good institutions, either public or private, than at home.

The writer desires to express his obligations for the illustrations which accompany this article to Dr. Walter E. Fernald, Superintendent of the Massachusetts School for Feeble-minded Children. *Pearce Bailey.*

INSECT FLOWERS.—*Pyrethri Flores. Insect Powder.* The half-expanded flower heads of *Pyrethrum cinerariæfolium* Trev. (*White* or *Dalmatian Insect Powder*) and of *Chrysanthemum roseum* Weber and *C. carneum* Weber, both called *C. coccineum* Willd. in the *Index Kewensis*, (*Blue, Caucasian* or *Persian Insect Powder*), all of the family *Compositæ*. The Dalmatian species is greatly superior. All are native and very extensively cultivated perennial herbs of western Asia. The heads bear a close resemblance to those of the common daisy, the rays being white in the Dalmatian, blue in the Persian. Insect flowers reach the hands of the consumers entirely in the form of the yellowish or gray powders, and it is then extremely difficult to determine their purity or quality, which varies most widely. The quality is claimed to be best when the heads are just beginning to expand, but their collection at this time is not economical. It decreases progressively with their maturity, but the use of

the mature or old flowers, being extremely difficult of detection, is obviously profitable, and constitutes the chief form of sophistication. Enormous quantities of the stems, which possess a very slight activity, are also ground with the flowers. Their presence is readily detected in the powder by the appearance of large whitish, glistening particles, chiefly of the fibres, and less readily by the greener color which they impart. The powder should have a clear greenish-yellow, but not a bright yellow color, the latter indicating curcuma, fustic, chrome yellow, or other coloring addition. It has a tea-like odor and an aromatic and bitterish taste. Its ethereal liquid extract, in the proportion of five parts of the filtered liquid to one of the powder used, should be of a handsome yellow, and on evaporation should yield a soft extract equalling 3.75 to 5.5 per cent. of the weight of the powder. Upon incineration, the powder should yield not more than 6.5 per cent. of ash, nearly all soluble in hydrochloric acid. These tests will determine the presence of nearly all of the very numerous adulterants which have been employed. Others are detected by the use of the microscope, but this requires considerable experience. A powder from flowers which have become too old exhibits characteristic seed tissues and yields considerable fat, of which there is but a trace in the young flowers. The powder is more active in proportion to its fineness.

No analysis of the constituents of insect powder yet made is conclusive as to the identity of the toxic agent. There are (1) volatile oil ranging up to 0.5 per cent., most abundant in the youngest flowers; (2) four to seven per cent. of resin, about two-thirds of it alcohol-soluble, the rest ether-soluble; (3) fat, from a trace in the youngest flowers to a considerable amount after the seed has formed. With these are ordinary plant principles. An alkaloid, a glucoside, and a volatile acid have been indefinitely reported. It is a curious fact that the toxic properties are imparted alike to alcohol or hot or cold water, or to the atmosphere by burning. The death of insects by contact with the fine powder is only partly mechanical, for Jelliffe has shown that while the stem powder is thus fatal to some, it does not affect others, which, however, are promptly killed by contact with the powder of the flowers. Insect powder does not affect the insect's eggs.

Although this substance is somewhat irritating, its tincture sometimes even causing vesication of the skin, yet its medicinal action is of no importance, and its one use is for the destruction of insect vermin. Here it has the great advantage over nearly all similar agents of being non-poisonous. It not only destroys such domestic pests as roaches, flies, bedbugs, and fleas, but is very useful as applied to insect-infected plants, either in the house or in the field. For the latter purposes it is best sprayed in the form of a decoction. Mosquitoes may be destroyed in a closed room by slowly burning a half-ounce or an ounce of the powder. *Henry H. Rusby.*

INSECTS, PARASITIC.—The group of insects as formerly understood included four sub-classes: the *Malacopoda*, consisting of a few worm-like forms; the *Myriopoda*, centipedes and millipedes; the *Arachnida*, spiders, mites, and ticks; and the *Hexapoda*, or six-footed winged division. While these groups all agree in having jointed bodies with jointed appendages and breathing by means of tracheæ, there is so much divergence in other respects that they are now separated into distinct classes and the *Arachnida* especially considered as widely different.

The INSECTA proper, or HEXAPODA, are bilaterally symmetrical animals having jointed bodies with jointed appendages, the body consisting of three distinct regions, the head, thorax, and abdomen, the former of which bears jointed antennæ and variously modified mouth parts; the thorax (consisting of three segments, pro-, meso-, and meta-) bears on each segment a pair of legs and on the meso- and metathorax each a pair of wings. Respiration is provided for by means of tracheal tubes which ramify throughout the tissues, carrying air to all parts of the body. Exceptional forms, especially among the parasitic species, occur in which the wings may be aborted or entirely wanting or in which different organs may be more or less aborted. It rarely happens, however, that these reductions go so far, but that the insect structure may be recognized at least during some brief period in the life history of the species.

Of the sixteen to nineteen orders which are recognized by different authors, but four include groups which are parasitic on man or the domestic animals with which he is most closely associated. These orders are the *Diptera* or two-winged flies, mosquitoes, etc.; the *Siphonaptera* or fleas; the *Hemiptera* or bugs, lice, etc., and the *Mallophaga* or bird-lice.

Of the other orders there are quite a number that may have an incidental importance, as the stinging *Hymenoptera* to be mentioned under *Insects, Poisonous*; the beetles, *Coleoptera*, some of which produce vesicating properties and others which at times cause trouble by getting into eyes or ears, and the *Lepidoptera*, many of which have larvæ that have nettling properties. To give mere mention to all of these phases would outrun the limits of this article, and our further attention therefore will be directed to such orders as include parasitic, or at least, semiparasitic, habits and affect the human species.

Diptera.—Two-winged insects, flies, mosquitoes, gnats, etc. Mouth parts fitted for piercing or sucking; a pair of mesothoracic wings and a pair of modified structures, halteres, or balancers, occupying the position of the metathoracic wings. Many of the members of this order affect man, but in such manner that it is often difficult to decide just where they should be placed. The mosquito, for instance, sucks the blood of man and might be counted semiparasitic, but its bite is poisonous and so it may properly be included under the section of poisonous insects, where discussion of its habits in this connection is given. It has further a most important relation as the medium for transmission of certain diseases, and this pathological relation is covered in an article on *Mosquito in Relation to Human Pathology*, by Professor Ward. The gad-flies or horse-flies seem on the whole to be better treated in connection with the poisonous insects and are so placed. Some other forms cause extreme annoyance by getting into the eyes, nostrils, and ears, causing intense irritation and sometimes requiring medical attention. The Hippelates flies, described by Dr. Schwarz from occurrences in Florida, are among the worst of these, and aside from the great annoyance and suffering may induce severe inflammation, and moreover are a menace as possible carriers of diseases of the eye or disorders of the skin.

Œstridæ or bot-flies comprise a well-marked family distinguished by heavy body, generally hairy, and with small eyes at the sides of the head. The antennæ are sunken into deep pits on the front; the mouth parts are rudimentary, and no food is taken in the adult stage.

The larvæ, which are the parasitic stage, are fleshy grubs and occur in different regions of the body of the host, such as the alimentary canal (horse bot), the nasal passages (sheep bot), the subcutaneous tissue (*Hypoderma* of cattle and, accidentally, in man, and the *Dermatobia* in man). Eggs are deposited on the body or attached to the hairs of the host to be, and newly hatched young reach the cavities they infest by various routes for the different species. While no species is to be regarded as strictly a human parasite, the occurrence of bots in man is of sufficient frequency to require mention here and consideration of the conditions under which they may infest the human species or become subjects for the practitioner.

Instances of the occurrence of the ox warble, *Hypoderma bovis*, and *H. lineata* in man have been recorded in both Europe and America. The former is the common species in Europe and its occurrence in man is noted as fairly common in Norway. The latter, which is the species occurring in America, has but few recorded instances, one of the best authenticated being that mentioned by Dr. John Hamilton (*Ent. News*, iv., p. 219). Their presence will be recognized from the swollen ulcers at different points under the skin, and there is a strong

tendency for them to migrate from place to place, though in the case reported by Dr. Hamilton, which ended fatally, the location was in an ulcer at the root of the tongue.

Œstrus hominis L. = *Dermatobia noxialis* Goudot. This, the species which has been termed the bot-fly of man, is of frequent occurrence in tropical America where it is a pest to cattle, as well as to dogs, monkeys, and other mammals; its occurrence on man being occasional, per-

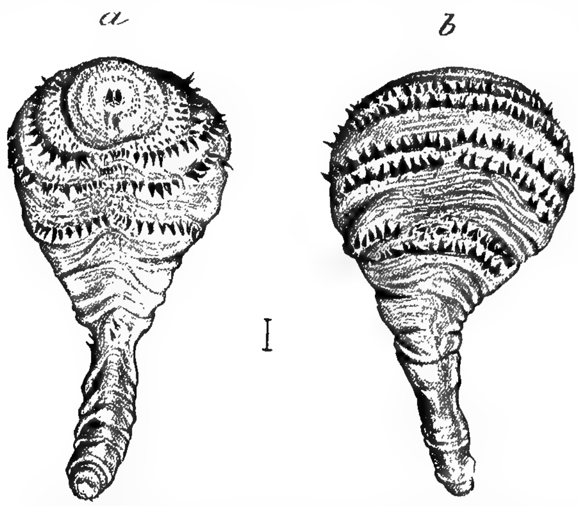

FIG. 2853.—*Dermatobia noxialis.* Larva. *a*, Ventral aspect and appearance of cephalic and caudal extremities, also the three rows of spines, single below and the point where the double rows end; *b*, dorsal view shows that the three rows of spines single below are double above. Greatly enlarged. (From *Insect Life.*)

haps accidental, as a result of deposition of eggs on the bodies of persons exposed, as when bathing, or the exposed parts of the bodies of natives.

The insect has a variety of names in different countries: *Ver macaque* in Cayenne and Mexico, *Ura* in Brazil (Para), *Torcel* in Costa Rica, and *Gusano peludo* or *Muche* in New Granada.

The larvæ are very characteristic in shape as shown in

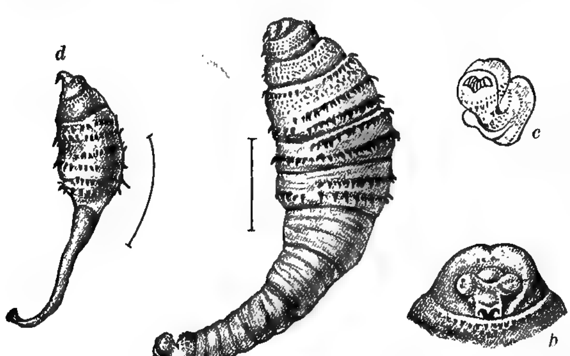

FIG. 2854.—*Dermatobia.* *a*, Brauer's figure of a larva and *d* Coquerel's figure of one probably identical with *noxialis*, differences due to maturity or to amount of contraction at time of preservation; *b*, cephalic extremity; *d*, caudal extremity of *a* enlarged; lines show actual length. (From *Insect Life.*)

the figure, the head end being broad and the terminal segments much attenuated.

If undisturbed they complete their growth in the subcutaneous tissue, and then issue to enter the ground and pass the remaining stages of development, issuing later as adult flies. In man they are probably as a rule extracted before they acquire maturity, since they could scarcely escape notice, and even crude surgery is sufficient for their extraction.

The larvæ are to be separated from the related *cyaniventris* by the minute spines on segments two and three,

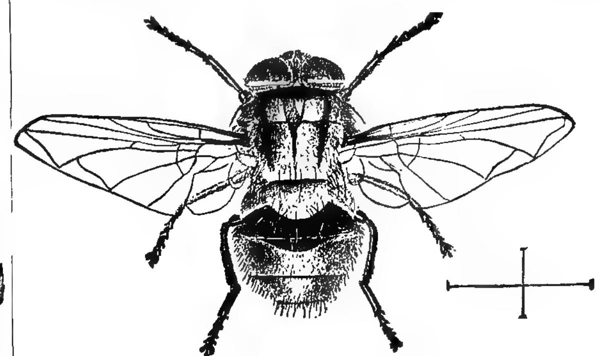

FIG. 2855.—*Compsomyia macellaria.* Adult; wings expanded. Enlarged. (After Francis.)

and the absence of hooks on the posterior borders of segments four to seven.

Dermatobia cyaniventris with similar habits has been separated from *noxialis* by Blanchard, the larva being said to have no fine spines on segments two and three, and a row of strong hooks projecting from the hind border of segments four to seven and sometimes eight.

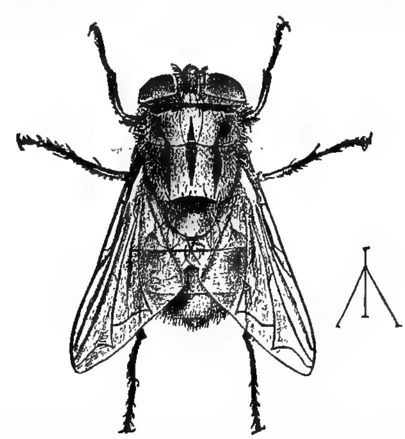

FIG. 2856.—*Compsomyia macellaria.* Adult; wings at rest. Enlarged. (After Francis.)

Muscidæ. Thick-bodied hairy flies, with well-developed mouth parts, either fitted for piercing or, as in the house-fly with soft membranous proboscis, adapted to liquid food. Larvæ, fleshy footless grubs or maggots, living in decaying matter, ordure, etc. The group is a large one, many of which, though not strictly parasitic, may seriously affect man. The common house-fly, for example, aside from being a great annoyance, is undoubtedly

FIG. 2857.—Egg of *Compsomyia macellaria.* Greatly enlarged. (After Francis.)

FIG. 2858.—*Compsomyia macellaria.* Egg mass greatly enlarged. (After Francis.)

a menace to health, since it may readily visit first the fæces of a typhoid patient and then the food of table or camp. Much of the typhoid occurring in the camps during the Spanish-American war is attributed to this means

of transmissal. Patients in hospitals may serve as centres of infection for ophthalmia and other diseases in adjacent dwellings, unless care is taken rigidly to exclude flies by means of close-fitting screens. It is also asserted that they may transmit the eggs of nematode and cestode worms. A number of the species which ordinarily deposit their eggs in decaying organic matter may on occasion deposit them in wounds and cause very serious results. The flesh-fly (*Sarcophaga carnaria*), meat-fly (*Calliphora vomitoria*), blue-bottle fly (*Lucilia cæsar*), and others, are injurious in this way.

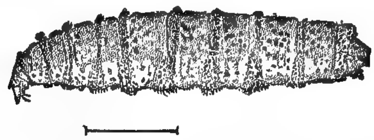

FIG. 2859. — *Compsomyia macellaria.* Larva enlarged. (After Francis.)

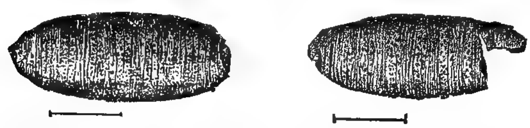

FIG. 2860.—*Compsomyia macellaria.* Puparia, entire at left and broken at right showing where fly has escaped. Enlarged. (After Francis.)

Compsomyia macellaria, the *Lucilia hominivorus* of early writers, the much-dreaded "screw worm" of the warmer portions of America, is undoubtedly one of the most important species that directly affect the human species. The head is red-brown; the thorax and abdomen are bluish-green with metallic reflections, and there are three longitudinal black stripes on the thorax. It is known all the way from Canada to Patagonia and has received a great number of technical names. The eggs are deposited on various decomposing substances, but not rarely in the nostrils of individuals when sleeping, or even when awake if exposed, but probably attracted as a rule by a catarrhal condition of the person. Eggs are small, cylindrical, white, with a ridge along one side. They hatch very soon after deposition so that the opportunity for removing them is very short. The larvæ on hatching work into the surrounding tissue, and the result of their burrowing is to destroy all the tissues of the soft palate, and cases are on record in which the vertebræ and os hyoides and other bones have been completely laid bare, such cases usually terminating fatally.

As many as three hundred maggots have been dislodged from the mouth and nose of an affected individual, and considering the rapid growth of such larvæ, it is not to be wondered at that the tissues are destroyed with great rapidity. Prompt attention is therefore the most essential element in treatment, and irrigation with dilute solutions of phenol, of clove oil, warm water, or careful use of chloral are recommended. Pyrethrum is stated to be a certain remedy in all cases in which the maggots can be reached with it.

Order SIPHONAPTERA—wings absent; sides with horny plates; body much compressed; the legs long and stout, the coxæ being remarkably developed; thoracic segments distinct; mouth parts fitted for suction, all the species in the adult stage feeding upon the blood of mammals or birds. Antennæ small, sunken in pits or grooves in the side of the head, of modified shapes, sometimes annulated and in other cases divided into leaf-like plates. Eyes simple or often reduced to mere rudiments or apparently wanting. Tarsi five-jointed.

They undergo complete metamorphosis, the larvæ being slender, worm-like, active creatures, feeding in the litter of dog kennels or other waste material where they may get access to dried blood or animal matter; the pupæ are quiescent, and the adults seek and live more or less constantly on the bodies of the host animal. Development proceeds rapidly in warm weather, the egg stage lasting about six days, the larval period a few days, and the pupa stage a week or more. Observations on some of the species shows that the entire life cycle from egg to adult may be passed in a fortnight.

Three families are now recognized, the *Sarcopsyllidæ*, *Vermipsyllidæ*, and *Pulicidæ*, the first and last including species affecting man.

Sarcopsyllidæ. Small forms with large heads, the gravid females confined to the host animal usually becoming embedded in the tissues.

Sarcopsylla penetrans Linn., the "jigger," "jigger flea," "chigoe," and "chique." Head angular; hind angles of the metathoracic scales rounded; eyes and antennæ in an-

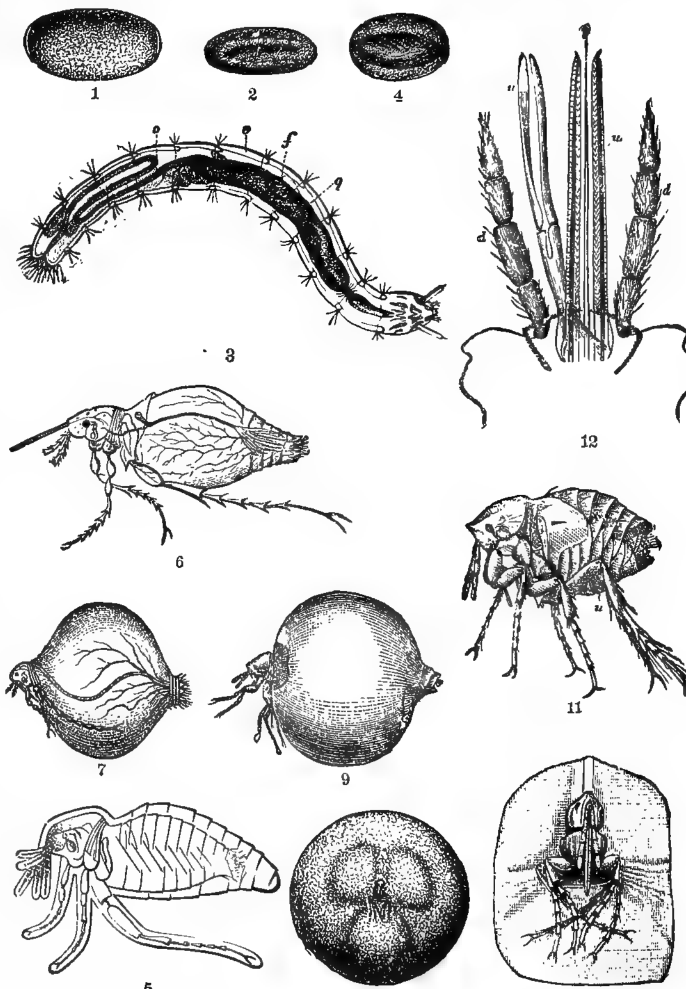

FIG. 2861.—*Sarcopsylla penetrans.* 1, Egg; 2, embryo; 3, larva; 4, cocoon; 5, pupa; 6, fecundated female; 7, the same on the third day from its entrance under the skin of its human host; 8, the same after several days' residence in the skin of its host; 9, fully grown female—magnified four times; 10, head of same still more enlarged; 11, female before entering the skin; 12, mouth parts much enlarged: *m*, mandibles; *d*, maxillary palpi; *u*, labium. (After Karsten and Guyon.)

terior part of head. The males and females are similar and flea-like, but when gorged with eggs the females lose all semblance to their original form.

The species has been noted particularly as a pest of man, but it is a very serious parasite of many other ani-

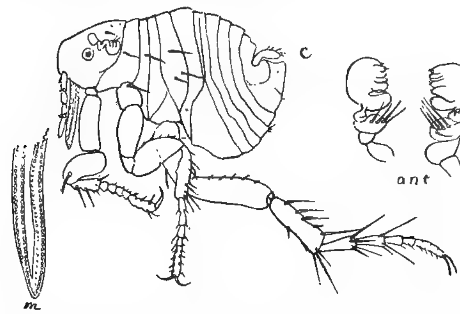

FIG. 2862. — *Sarcopsylla gallinacea.* Male. Enlarged. *ant*, antennæ; *m*, palpi, more enlarged. (From *Insect Life*, drawn by Packard.)

mals also. It appears to have been a native of tropical America, but has been carried to other countries and especially in Africa is said to have spread with astonishing rapidity.

The adults attack animals as in other species, but the females after being impregnated burrow into the skin, especially beneath the toe nails in man, and there produce a swelling and later a distinct ulcer, which in some cases results fatally. The development of the eggs greatly distends the body of the insect so as markedly to change its form, the head and legs appearing as little appendages on a large round body as big as a pea. Each female is said to produce about sixty eggs, which are deposited in a sort of sac, and the young hatch and feed upon the swollen body of their mother until they are full grown, when they escape to the ground. Removal of the parasite is accomplished by the introduction of a sharp knife point, the object being to extract the insect entire as the bursting of its skin and discharge of its contents in the skin are likely to produce distressing sores.

Sarcopsylla gallinacea Westw., hen flea. Head obtusely pointed in front; the antennæ and eyes are in the posterior half of the head; the metathoracic scales angled behind, 1 to 1.5 mm. long. This species appears to have been introduced into the Southern States probably from the Old World, and it has been observed in Florida, Mississippi, Texas, and Oklahoma, and is likely to spread over the warmer part of the country at least. Its main attack is upon domestic fowls, but it is stated to attack man, especially children. The females bury themselves in the skin as in the preceding species and the sores produced are of a similar character. The effects upon young chickens and puppies are said to be very serious and the results often fatal. But little has been ascertained regarding its effects on the human species.

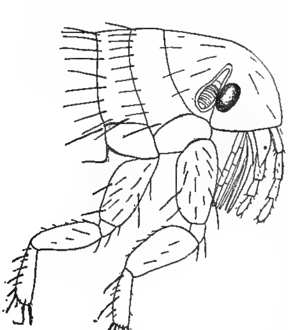

FIG. 2863.—*Pulex irritans.* Head and pronotum, showing form and absence of combs. (Author's illustration, Bull. United States Dep. Ag.)

Pulicidæ. Labial palpi three- to five-jointed. The abdomen of the female does not become especially swollen with the development of the eggs.

Pulex irritans L., the house flea, is recognized by the absence of combs of spines on the border of the head and pronotum, and the length of the hypopharynx and mandibles which reach more than half-way on the fore coxæ, the single row of bristles on the abdominal segments, the large male claspers, and the dark reddish or piceous color. It has a very wide distribution over the world, and has been a familiar if not welcome guest in dwellings from remote antiquity. Their attacks for blood sucking are made more particularly at night, but they have none of the secretive habit of the bedbug, depending on their agility and enormous leaps to escape from capture. Eggs are deposited in out-of-the-way places, in cracks and under carpets where the young may secure a supply of organic matter of various sorts to serve them as a food supply. Each female is supposed to deposit from eight to twelve eggs, which are whitish ovoid, less than a millimetre in length, and which hatch in the course of from four to six days in summer and which reach the pupa stage in about eleven days, from which they issue as adults in about twelve days later. The full life cycle may therefore be completed in the course of a month in summer and six weeks in winter. Preventive measures must be directed against the harbors for the development of the young, cleanliness in regard to the places where the eggs might hatch and the young develop being more effective than attention to other points, though the use of pyrethrum may be resorted to to destroy the adults.

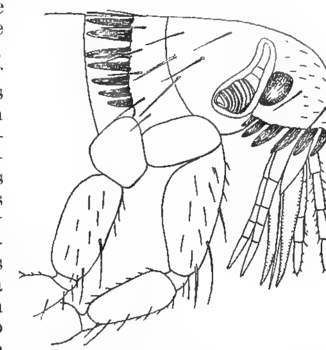

FIG. 2864.—*Pulex serraticeps.* Front part of body showing combs on head and pronotum, enlarged. (Author's illustration, Bull. United States Dep. Ag.)

Pulex serraticeps Gerv., the dog flea, recognized by the distinct comb of spines on the lower border of the head and on the hind border of the pronotum as shown in the figure, is in this country a more frequent pest in houses than the *irritans.* Its normal hosts are the dog and cat, but it seems thoroughly at home on the human species and is an extremely annoying pest. Eggs are attached to the hairs of the dog or cat, but so loosely that they drop off easily and are scattered wherever these animals may chance to rest. Both of these species are more annoying than dangerous, their bites seldom causing more than temporary inconvenience; but it is easily conceivable that they might become the carriers of the germs of infectious disease or of septic matter, and thereby assume a very different rôle.

Order HEMIPTERA—insects with suctorial mouth parts; four wings, unless aborted or rudimentary, the upper or

FIG. 2865.—*Cimex lectularius.* Head and prothorax much enlarged. (Author's illustration, Bull. United States Dep. Ag.)

front pair being thickened at their bases. The young hatch in the form of the adults.

Cimicidæ, wings aborted or if present with simple membrane; the parasitic or semiparasitic bedbug having mere rudiments of wings.

Cimex lectularius, bedbug. Known in different localities as chinches, chintzes, redcoats, mahogany flats, etc. It has infested human habitations since the dawn of history and is distributed over practically the whole world even into northern regions. The body is very thin and flat, oval in outline, the head sunken in the prothorax, the margins of which are finely ciliate. The antennæ

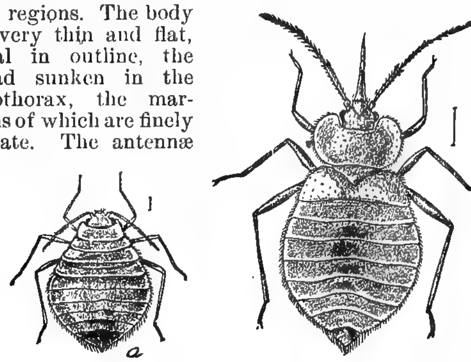

FIG. 2866.—*Cimex lectularius.* *a*, Young. Both enlarged. (From Riley, United States Dep. Ag.)

are slender, the three distal joints about equal in length and covered with fine hairs. The wing pads are very small and never known to become fully developed. The color is light yellowish to dark reddish-brown, depending on age and the contents of the body. It has a very characteristic odor similar to that of the chinch bug and many of the other species of this order. The odor would seem to be of no advantage to the bug under present conditions, and may be looked upon as a survival. The habits are nocturnal, the insect sucking the blood of man at night, and secreting itself during the day-time in cracks of furniture or walls. Its bite is in some degree poisonous, affecting some persons much more seriously than others, but is apparently due to irritation of puncture or simply the juices of the mouth, as no poison glands have been detected. Individuals hibernate or, where warm enough and conditions favor, reproduction may proceed throughout most of the year, but is most

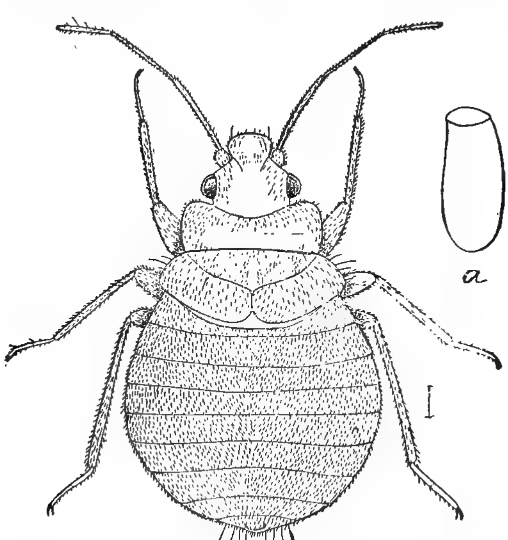

FIG. 2867.—*Acanthia inodora.* Female. *a*, Outline of egg enlarged. (Author's illustration, Bull. United States Dep. Ag.)

rapid in warm weather. A period of seven to ten weeks or more is occupied from egg to adult, but varies greatly depending on temperature and food. They may survive long periods without food, but development is retarded. Irritation of the bites may in extreme cases require the attention of the physician, but ordinarily effort should be directed toward prevention. In well-kept homes the extermination is a matter of persistent use of well-known household measures, but in hospitals, asylums, prisons, and other institutions where large numbers of people of varied habits and history are brought together the problem may become more serious. In extreme cases fumigation of rooms or of whole buildings may be the quickest way to secure relief. An effective plan is to clear the room or rooms of all objects that would be tarnished or bleached by the process and then burn brimstone in a small dish set within a larger one so as to avoid possible fire from overflow of the burning material. Close all openings even down to the keyhole and leave the room for several hours after which it may be opened and thoroughly aired. Recent experiments have shown that Hydrocyanic acid gas can be used with best of results for these and other "vermin" in prisons and other buildings and in railway coaches or sleeping cars, where it is possible to vacate the structure and close it tight enough to confine the fumes.

Acanthia inodora Duges, "Coruco" or Mexican chicken bug. This species has been described as infesting poultry in Mexico and New Mexico and is also stated to be a very serious pest in houses. According to information recorded by Townsend it used "to swarm in military posts to such an extent that the soldiers were ordered out and formed in two lines, one with brooms to sweep the corucos en masse up against an adobe wall where the other line stood ready with trowels and mud and plastered them into the wall alive."

There are other species of this genus which sometimes cause alarm by their abundance where swallows or bats congregate from the supposition that they are in this manner introduced into houses.

A. hirundinis Jenyns swarms in enormous numbers in the nests of the barn swallow, and may scatter over the building, but so far as known never enters houses or preys upon other than the swallows.

A. pipistrelli Jenyns preys upon the bat and swarms in places where these animals secrete themselves during the day.

A. columbarius Jenyns is recorded as infesting dovecotes in Europe, but has not been recorded so far as I know for America.

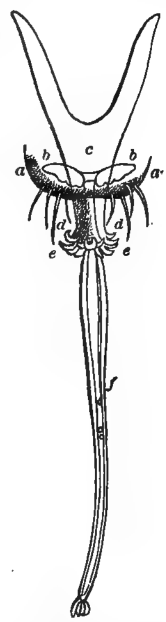

FIG. 2868.—Mouth parts of Louse (*Pediculus vestimenti*). *a, a*, The summit of the head with four bristles on each side; *b, b*, the chitinous band; *c*, the hind part of the lower lip; *d, d*, the foremost protruding part of the lower lip (the haustellum); *e, e*, the hooks turned outward; *f*, the inner tube of suction slightly bent and twisted; the two pairs of jaws are perceived on the outside as thin lines. (After Packard.)

Sub-order *Parasita.* These are strictly parasitic insects, being confined to their hosts constantly and deriving all their nourishment from them. They are wingless, and the mouth parts consist of a tubular suctorial organ. There are two divisions of the group, the one including the forms which have a three-jointed beak and which are parasitic exclusively on bats, and which may be disregarded here, the other including our common lice mention of which follows.

Pediculidæ. Rostrum very short, unjointed but surmounted by a circle of hooks; eyes reduced; antennæ three- to five-jointed; thorax with segments not sharply separated; legs thick; tarsi with a single strong claw usually fitting against a spur of the tibia; abdomen usually nine-jointed. The egg "nits" are attached to the hair of the host, and the young have the same form as the adults and like them cling closely to the host animal.

The species are, so far as known, very closely restricted to one species of animal or at most to a few closely related species in the same genus, a fact which indicates a very perfect adaptation to a particular host and which may mean some particular adaptation of the mouth parts of each to the thickness or texture of the skin of its special host. The mouth parts in all cases must be capable of considerable extension, and the mechanism for probing into the skin so that the capillaries may be reached is quite complex. The fleshy rostrum is surmounted by a circlet of hooks which as the organ is extruded embed themselves in the skin and thus furnish a firm grasp whereby the tubular suctorial organ consisting of four delicate bristles may be gradually forced through the outer skin and down to the capillaries. This tube terminates, in *vestimenti* at least, in a delicate set of lobes which are supposed to act as tactile organs in feeling the way through the dermal cells. When the blood-vessels are reached a current is maintained by the pulsations of the pumping stomach. The injury which results from these infestations is the annoyance and irritation of their presence, and *phthiriasis* as a specific disease, meaning anything more than infestation or "lousiness," has been shown to be a misnomer. The ancient accounts of frightful and fatal consequences due to the presence of these parasites must be exaggerations or the lice have been charged with being the cause of diseases due to some other agent. Since none of the species affecting lower animals is known to be transmissible to man we may omit them from the discussion of particular species.

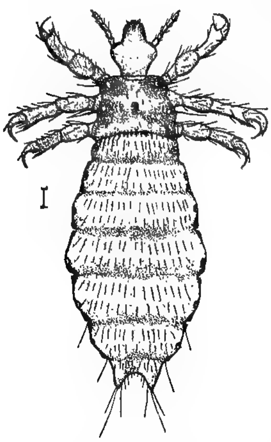

FIG. 2869.—*Pediculus capitis.* (Original.)

Pediculus capitis Degeer, head louse. Whitish with faint markings on the dorsum of thorax and abdomen and usually, in adults, distinct dark markings on the margins of the abdominal segments. The last segment of the abdomen is bilobed. This species has been recognized under one name or another during all historic time and its ancestry doubtless runs back to primitive man. While most commonly found on children it may multiply in unkept hair of adults as well, but it seldom occurs elsewhere on the body than amongst the fine hair of the head. The eggs or "nits" are white and glued to the hair at some distance from the roots and are in most cases placed more abundantly behind the ears. When numerous they form quite conspicuous objects and serve as a good diagnostic feature. The newly hatched lice resemble the adults except in size, and in being less distinctly marked, and the proportions of the body vary slightly, the abdomen being smaller in proportion to the head and thorax.

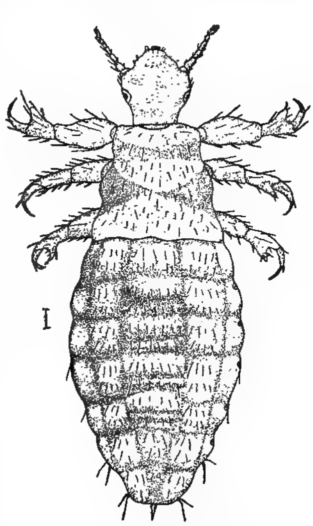

FIG. 2870.—*Pediculus vestimenti.* (Original.)

Murray has shown that the different races of man harbor different varieties of this species of louse, the difference in the varieties being particularly in color and in the form of the claws. In color they differ from the nearly white infesting the Caucasian to the black infesting the African. The claws differ somewhat in proportions, and Murray thinks these differences constant.

Most cases will respond promptly to cleanly habits, but aggravated cases in asylums or poor-houses may require more heroic methods and the mercurial preparations are probably as effective as any.

Pediculus vestimenti Leach, the body louse. Like the preceding species this insect is whitish, but it has in maturity more definite markings which give it a grayish-white appearance and gained for it the name "grayback." It is slightly larger, the head scarcely as protruding in front; the end of the abdomen not so markedly lobed or almost entire. Like the preceding species it has been a familiar object though not always recognized as a separate species. It is more common where opportunities for good sanitation are wanting, as in armies, prisons, or other places where many people are brought together under conditions that prevent due regard to cleanliness. It is said to occur on the body, most frequently on the nape of the neck, but secretes itself in the clothing when not actually engaged in sucking blood. The long slender sucking tube, by means of which it reaches the blood, is shown fully extended in Fig. 2868. The eggs are deposited in the folds of the clothing, and, according to the estimates of Leeuwenhoek, an adult female may have a progeny of five thousand in eight weeks, an estimate which he believed might be increased in the heat of summer. There is abundant basis in this estimate for all the rational accounts of excessive numbers of this parasite in certain cases. A ready means of destroying the pest is thoroughly to heat the infested clothing by boiling or by heating in an oven up to the point where both eggs and lice will be destroyed, which is considerably less than what would scorch the clothing. Fumigation may also be used.

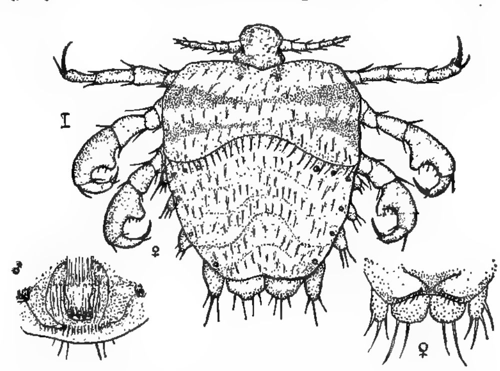

FIG. 2871.—*Phthirius inguinalis.* Female; dorsal view. Male; tip of abdomen. (Original.)

Under the name *Pediculus tabescentium* Alt described the form which he considered as the cause of *phthiriasis*, but later writers have referred his observation and description to aggravated cases of *vestimenti.*

Phthirius inguinalis Leach. This species is very distinct from the other species occurring on man, the body being nearly as wide as long, and the spreading legs, which extend laterally far beyond the borders of the body, give it a decidedly crab-like appearance. This has given it the name of "crab-louse." It confines itself particularly to the coarse hair of the body, especially the pubic region, but may occur also on the coarse hairs of the arm pits, in the beard, and is said also to cling to the eyebrows. It is of a whitish color, with dusky patches on the thorax, the legs slightly tinged with reddish and the

Insects.

claw having this color more pronounced. On the borders of the abdomen there are a number of prominent lobes, and the spiracles are so arranged that three lie transversely each side at the base of the abdomen. In the female there are prominent lobes with stiff bristles meeting on the ventral side near the tip. It is nearly one-tenth of an inch (2.5 mm.) in length.

Its attacks are said to be more severe than those of the other species, and the young, by burrowing under the epidermis cause an intolerable itching. The eggs, as with other species of lice, are attached to the hairs.

Infection may come from occupying quarters previously used by an infested person, but no person of cleanly habits is likely to be long troubled with them. For severe cases use of mercurial applications may be recommended. *Herbert Osborn.*

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INSECTS, POISONOUS.—As generally classified, a poisonous insect may be almost any of the *Arthropoda* that have the property of producing poisonous effects in man or in the higher animals; and it seems necessary, therefore, in this article, to refer to some forms that are not in the strict zoological sense insects or members of the group *Hexapoda.*

We may preface a discussion of the particular forms of poisonous insects by a few comparative statements regarding the organs concerned in the production of venomous material, the nature of the poison, and the means by which it is injected into the system of the victim. In all cases in which there is a true injection of venom or poisonous principle there is a development of glands concerned in the secretion, and these glands may be variously located, depending on whether the wound is caused by the mouth parts or by a sting. The mandibles of the spider and the solpugid, and of certain varieties of ants, as also the piercing mouth parts of the bug and mosquito (modified mandibles), are the organs of injection; and, as might be supposed, the glands connected with these organs are specialized salivary glands which have taken on the function of secreting a venomous fluid. The sting of the bee or wasp is a modified ovipositor, while the sting of the scorpion appears to be an independent structure possessing a venomous function only. In both these cases the glands are probably specialized dermal glands which, traced back, may be found homologous with the coxal glands of general distribution in more primitive groups. The venomous secretion, in most cases in which it has been investigated, is of a formic acid, or similar nature. Its effect is corrosive, and the symptoms usually noted are rapid swelling and inflammation; often numbness or partial paralysis occurs; while in more extreme cases a general effect on the nervous system extending to the nerve centres is produced. The distinctly paralyzing effect on the nerve centres is especially the work of certain wasps which sting their prey in order to render it helpless and inactive, while its life is spared that the body may serve as a lasting food supply for the young hatched from eggs deposited at the

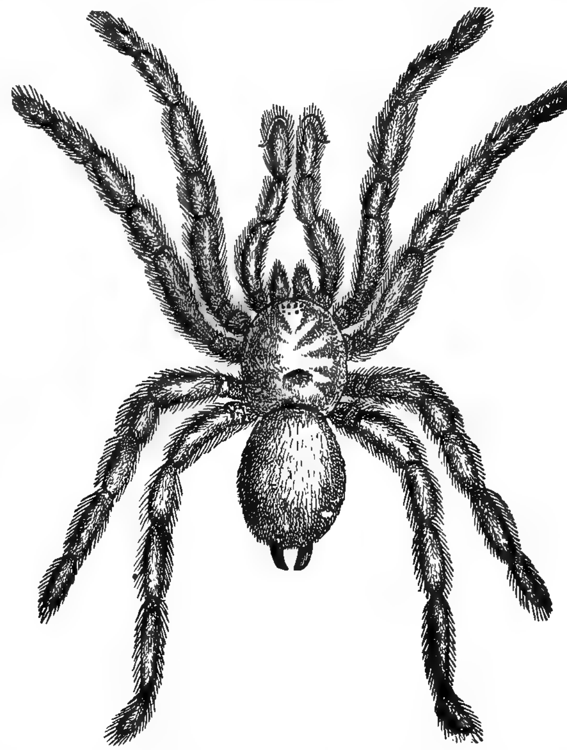

FIG. 2872.—Bird Spider (*Mygale hentzii*). (From *American Entomologist.*)

time these hapless victims are captured and put in "cold storage." In the scorpion the venom affects the blood corpuscles. The effects of insect bites or stings vary greatly with the susceptibility of the victim and with the condition of the poisonous insect at the time the poison is injected. Evidently the secretion of the gland may be exhausted by prolonged activity, so that after a succession of bites or stings the effect may be slight; while the virulence is doubtless influenced also by the state of irritability or activity of the insect. Since the poison is almost invariably an acid, the general antidote is some form of alkaline base, as magnesia or lime and their car-

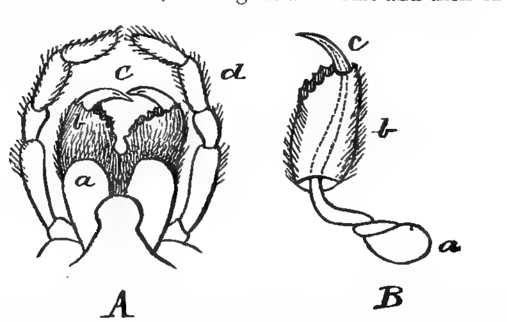

FIG. 2873.—*A*, Mouth Parts of Genuine Tarantula (*Tarantula fasciventris*); *a*, palpi; *b*, mandibles; *c*, fang. *B*, Fang and poison-gland; *a*, twisted poison gland; *b*, mandibles; *c*, fang with outlet for poison. (From the Gartenlaube.)

bonates, ammonia, etc.; particular antidotes are recommended further on, however, in a number of special cases.

Among the group of spiders, scorpions, etc., known as *Arachnida*—distinguished by the presence of two body

regions, four pairs of legs, a number of simple eyes, but no compound eyes or antennæ—there are certain poisonous species that shall first receive attention.

Araneidæ, Spiders. Body of two regions, the abdomen connected by a slender pedicel; mandibles two-jointed, the outer forming a claw or fang folding against the inner. A poison gland located in the basal joint opens through a duct at or near the tip of the fang. Of this variety, the bird spiders or American "tarantulas" are the most formidable in appearance, some of them reaching a great size, being strong enough to capture small birds. Some of the tropical species occasionally reach Northern cities by being transported in banana bunches, and they cause considerable interest, if not some terror, when brought to light. Their bite is quite painful, though not necessarily dangerous, being often of such a nature as to need attention. Of native species we have two: one the *Mygale hentzii*, illustrated in the figure, which occurs throughout the Southern and Eastern part of the country; the other the *Mygale rileyi* Marx, which occurs on the Pacific coast. The bite of these two species is not very serious, though in the case of children or susceptible adults the effects may be rather alarming. The true tarantula belongs to a family called the wolf spiders, *Lycosidæ*, the European *Tarentula fasciventris* being the species popularly credited with causing all sorts of afflictions, and especially the affliction known as tarantismus or tarantula dance.

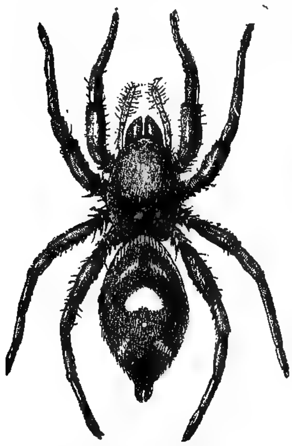

FIG. 2874.—Wolf Spider (*Phydippus tripunctatus*). (After Riley.)

Of the same family is the "malmagnatte" *Latrodectus malmignatus*, inhabiting Italy, Corsica, and the Antilles. It is recorded to have appeared in great numbers in Spain on different occasions, causing much terror on account of its poisonous bite. The *Latrodectus mactans* is charged with numerous serious bites in this country, some with a fatal termination. The records are for the most part wanting in specific details, and Dr. Howard has shown that a large part of such records may be due to other causes, and especially to the bites of Piratine bugs to be mentioned later. Still another wolf spider, the *Phydippus tripunctatus* L., has been stated by Riley to produce a serious bite, and he records in the first edition of this HANDBOOK an instance observed by Dr. Otto Lugger which would seem sufficiently exact in details to require credence.

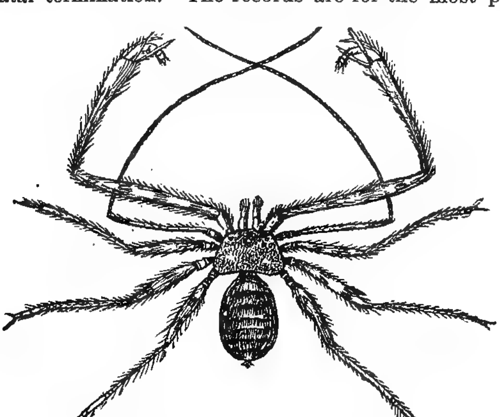

FIG. 2875.—*Phrynus lunatus*. (After Brockhaus.)

Pedipalpi.—The scorpion spiders combine the characteristics of the spider and of the true scorpion; they differ from the latter particularly in the absence of an elongated abdomen, with or without a tail but without a sting, the poisonous secretion, when present, being discharged through a fang like that of the spider. The bite of some of the species is serious, but is usually exaggerated in importance. In the genus *Phrynus* there are a number of species occurring in the Southwestern part of the United States, the group being confined to the warmer parts of the globe. In *Thelyphonus*, which has an elongated whip-like appendage to the more elongate abdomen, are the whip scorpions, which, though very formidable in appearance, have, it is claimed, no serious power of biting or poisonous effect on human beings.

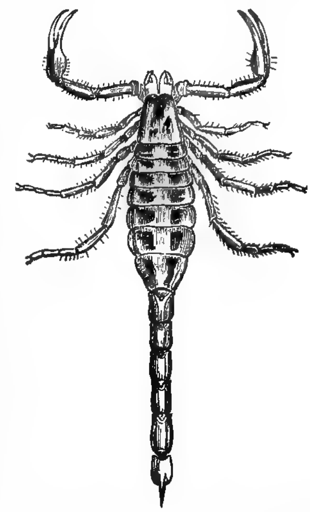

FIG. 2876. — Scorpion (*Buthus carolinus*.) (From *American Entomologist*.)

Scorpionidæ.—The scorpions are a very well-marked group of animals, being recognized at once by the large chelate palpi and the slender-jointed post-abdomen with its prominent up-turned sting at the tip. Two large ocelli are placed near together in the middle of the cephalothorax, and smaller lateral ocelli are arranged along the anterior margin. They are familiar objects in all tropical countries, and have always had a reputation for being dangerously poisonous, but in many cases their venomous nature has been greatly exaggerated. None of the species produces fatal or even very serious results, except it be upon very susceptible individuals. The sting is perforated at the tip, and the milky poisonous secretion is forced from the gland contained in the large bulbous telson or terminal segment of the abdomen. It is stated that the poison of the scorpion acts upon the red blood corpuscles, paralyzing them and causing them to become agglutinated, and thus to clog the capillaries and smaller blood-vessels. The symptoms are faintness, numbness, fever, tumors on the tongue, and dimness of vision. Ammonia alleviates the pain quickly, and ipe-

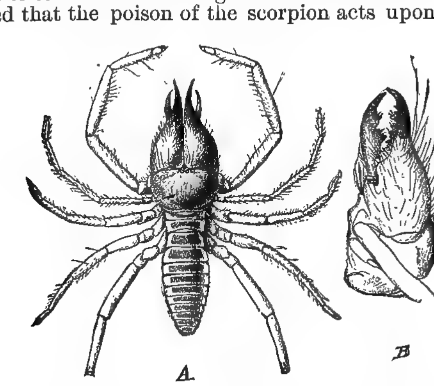

FIG. 2877.—*Datames striatus* Putn. *B*, Side view of head of female. (After Putnam.)

cacuanha may be administered to overcome the faintness. The common species in the Southern States is *Buthus carolinus*, but a number of species occur further to the southwest and become more numerous in Mexico and Central America. Old-World species are also numerous.

Solifugæ (Galeodidæ). Bodies elongate and thorax separated; the abdomen distinctly segmented. The mandibles are large and scissor-like, and the maxillary palpi leg-like. Respiration by tracheæ, and not by pulmonary sacs. These are very peculiar animals, with quite marked differences from any of the other groups of Arachnida. While they have been popularly credited with extreme poisonous properties, it is not known that they have really any serious effect on the larger animals that they may happen to bite. The mandibles are very large and strong, and they can certainly inflict a severe bite upon any of the smaller animals with which they may have to contend. They are found especially in dry regions, and in America occur in the plateau region from Colorado down to Central America, while different species are to be found all along the higher and drier portions of the American continent. In the Old World the desert or plain regions of Southern Asia and Russia are their haunts.

Myriopoda, centipedes and millipedes. Bodies long, with segments of nearly uniform size and no differentiation of thorax and abdomen. One pair of antennæ, three pairs of palpi, no compound eyes but a cluster of simple eyes. The *Diplopoda* or millipedes have cylindrical bodies and very numerous legs. The species are not poisonous.

Chilopoda. Body flattened, one pair of legs to each segment; antennæ long and many-jointed; mouth organs strong; poison glands opening in second postcephalic pair of appendages, which are strong and resemble mandibles. The centipedes, *Scolopendra*, are the most familiar species in this group, and have received much notice on account of their venomous bite, which, however, is seldom of a very serious character. Some of the species reach nearly a foot in length, but the majority of them range from four to six inches. *Scolopendra castaniceps* is the common centipede of the Southern States. It reaches a length of about six inches, and is of a yellowish-brown color with green borders to the segments.

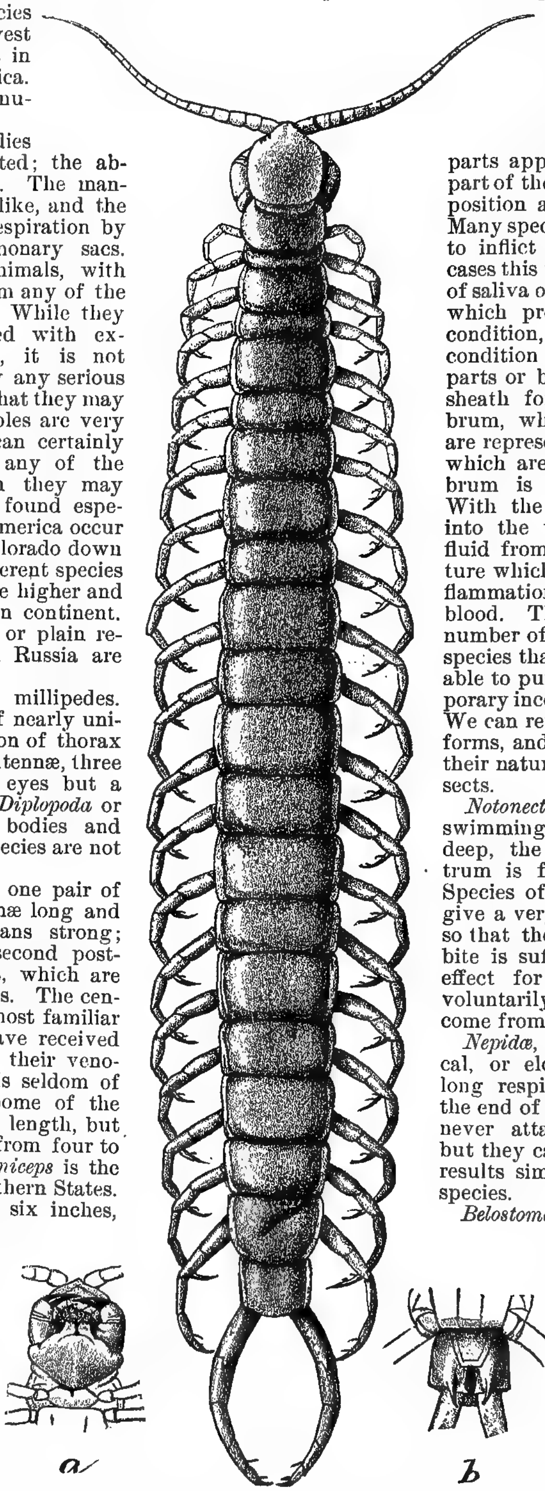

FIG. 2878.—*Scolopendra castaniceps*. *a*, Under side of head, showing fangs; *b*, under side of last segment. (After Wood.)

HEXAPODA.—Insects proper. Arthropods with three pairs of legs, usually two pairs of wings; the body regions well marked into head, thorax, and abdomen. Compound and simple eyes, one pair of antennæ. This group includes an immense number of forms, and authors recognize from sixteen to nineteen orders. But few of these include poisonous forms, though they may have important relation to man in one way or another. In the sub-order Homoptera of the Hemiptera, there are no strictly poisonous forms, but the Cicada, or seventeen-year locust, has been credited with a poisonous bite or sting, and this belief seems to persist among a considerable class of people.

Heteroptera. This sub-order of *Hemiptera* includes the bugs with wings thickened at the base, the apical portion remaining membranous, the mouth parts appearing to rise from the anterior part of the head, which lies in a horizontal position as regards the axis of the body. Many species in this group have the ability to inflict a severe wound, and in some cases this is accompanied with an injection of saliva or some of the fluids of the mouth which produce a more or less inflamed condition, and in some instances a serious condition of the patient. The mouth parts or beak consist of a well-developed sheath formed from the specialized labrum, while the mandibles and maxillæ are represented by slender setæ, the parts which are thrust into the flesh. The labrum is small and scarcely noticeable. With the plunging of the slender setæ into the wound there is a discharge of fluid from salivary glands of an acid nature which acts as a poison, producing inflammation and an accelerated flow of blood. This ability is shared by a large number of the species, even many of the species that feed normally on plants being able to puncture the skin and cause a temporary inconvenience if handled carelessly. We can refer only to the more troublesome forms, and most of these are carnivorous, their natural habit being to prey upon insects.

Notonectidæ, water boatmen. Aquatic, swimming with back downward, body deep, the back boat-shaped. The rostrum is four-jointed, strong, and acute. Species of our common genus *Notonecta* give a very sharp, painful bite if handled so that they can reach the skin, and the bite is sufficiently poisonous to leave an effect for several days. They do not voluntarily attack man, so that injuries come from handling them.

Nepidæ, water scorpions. Flat, elliptical, or elongate aquatic insects with a long respiratory tube extending beyond the end of the abdomen. These probably never attack man without provocation, but they can give a severe puncture with results similar to those of the preceding species.

Belostomatidæ, giant water bugs. Large, flat-bodied brown or gray insects with hind legs fringed with hair for swimming and the fore legs fitted for grasping insects or small fish upon which they prey. We have two very common species, *Belostoma americana* Leidy, which has a groove on the fore femora into which the tibiæ fit, and the *Benacus griseus* Say, of equal or larger size and scarcely distinguishable from the first except for the lack of the groove of the fore femora. Both are destructive to small fishes, and do not bite man except as they may be provoked by handling; and then their bite, though severe, is not dangerous unless extra-

neous matter has been introduced. These insects often appear in great numbers at electric lights during the summer time, and so are likely to attract attention and may be carelessly handled by people unaware of their painful bite.

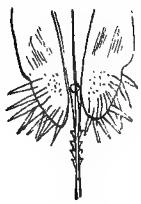

FIG. 2879.—Point of Beak of a Hemipteron.

Reduviidæ, pirate bugs. Heads prominent, projecting; antennæ tapering to tip; rostrum curved; wings usually with distinct cells. These are typically predaceous bugs, and nearly all have a poisonous bite. But few of them attack man except when handled or interfered with, but some seem to have acquired a decided taste for human blood. Howard attributes to members of this family many of the supposed spider bites, and the term "kissing bug," which had such an extensive run in the year 1899, was based on the bites of certain of these bugs.

Reduvius (*Opsicoetus*) *personatus* L., cannibal bug; "kissing bug." This species is about three-fourths of an inch long, of a dark brown nearly black color, the head rather small and the body rather trim. It is practically cosmopolitan, doubtless having been introduced into this country from Europe. Its bite is very painful, said to be worse than a bee sting, and the effect may be noticed for several days. The very serious results which have been reported in a few instances must, however, have been due to the introduction of septic matter carried on the beak, as the secretion of poison cannot be credited with such extreme effects. The name "kissing bug" was probably first applied to this form, and it may most properly be credited with the name as it is the most frequent in houses and the only species common in the northern part of the country where some of the first cases were reported under this popular name. The species is credited with preying upon the bedbug, and its attacks on man may be interpreted, if one so chooses, as an indication of a lack of its normal food.

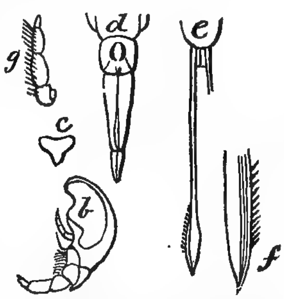

FIG. 2880.—Rostrum of *Notonecta.* *b,* Side view of rostrum; *d,* rostrum from above; *e,* one of the mandibles entire and the base of the other and of the two maxillæ; *f,* extremity of mandible more strongly magnified, with recurved teeth; *c,* labrum; *g,* antenna. (After Westwood.)

Melanolestes picipes, H. S., pirate bug. Black throughout, about 15 mm. long, closely resembles the following except in having the uniform black color. About equally common throughout the Northern United States, and extending south and west, occurring also in Mexico. It does not ordinarily occur in houses, but under logs and stones, where it preys upon various kinds of insects. It bites severely, but only when handled, probably never making an unprovoked attack on man.

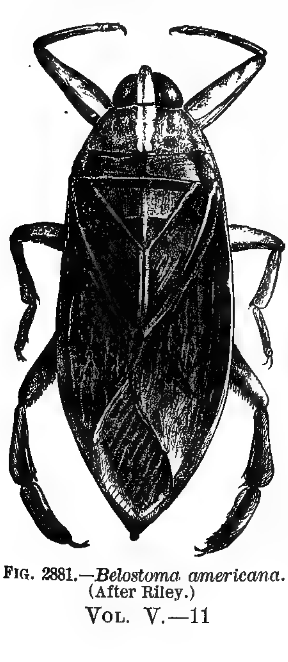

FIG. 2881.—*Belostoma americana.* (After Riley.)

Melanolestes abdominalis H. Schf., pirate bug. Distinguished from the preceding by having the abdomen, at least along the border, of a bright red color. It has at times been considered as a variety, but no very satisfactory proof is available. There is very frequently a variation in the wing length or the occurrence of apterous individuals, especially among the females, as shown in the figure. The beak is powerful, and the bite, like that of the preceding species, very painful. The habits are similar, and they will be found in like situations; when caught they should be handled in such manner that they cannot thrust the beak into the flesh.

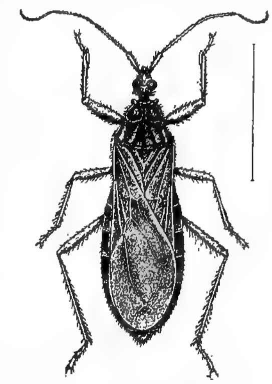

FIG. 2882.—*Reduvius personatus.* (After Howard, Bull. United States Dept. Ag.)

Rasahus biguttatus Say., "two-spotted Corsair." A large, strong species about three-fourths of an inch (16 mm.) long, black with reddish-brown prothorax, and a large orange-yellow round spot on the membrane of elytra. Distributed over the Southeastern United States, where it is a rather common species. Its bite is very severe, and results in severe cellulitis, the effects of which may continue for several days. No particular fear of serious effects need be entertained unless symptoms of septic poisoning appear.

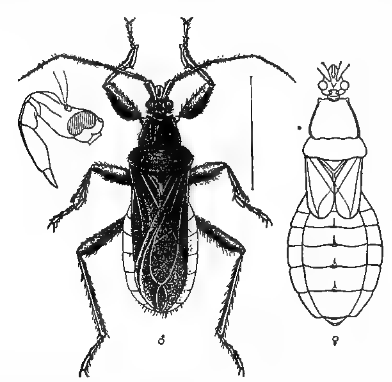

FIG. 2883.—*Melanolestes abdominalis.* Male at left, female at right; apterous form. Beak at left of male. (After Howard, United States Bull. Div. Ent. Dep. Ag.)

Rasahus thoracicus Stal. is a very similar species, occurring southwestward and in Mexico.

Conorhinus sanguisugus Le C., blood-sucking cone nose. Considerably flattened, the head more produced and the beak more slender than in the preceding group. The color is mainly a dark gray to blackish, with rather prominent bands on the side of the abdomen; the length is full three-fourths of an inch (16 to 17 mm.). The abdomen is broader than the thorax, and the anterior legs are not so much thickened as in the preceding forms.

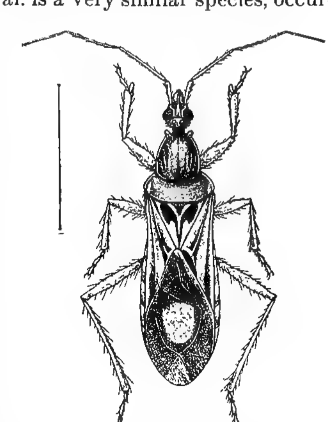

FIG. 2884.—*Rasahus biguttatus.* (After Howard, Bull. United States Dep. Ag. Div. Ent.)

This species is distributed over a large range of the country from the Ohio River southward. It is called the big bedbug in some localities on account of its habit of secreting itself in beds and attacking people who may occupy them. Its bite is very severe, the beak being so strong that it may be thrust through ordinary clothing, and its length sufficient (5 mm.) to reach well into the skin. Its puncture produces violent inflammation and swelling, and is likely to fester and discharge pus for several days.

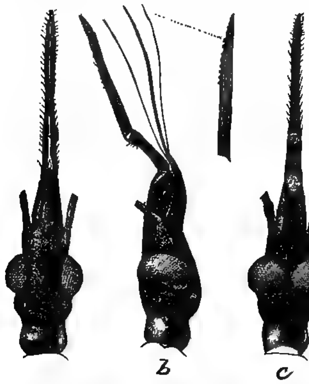

FIG. 2885.—*Conorhinus sanguisugus.* *a*, Showing beak; *b*, from side with setæ withdrawn and tip enlarged; *c*, head from below. All enlarged. (After Howard, United States Bull. Dep. Ag.)

Closely related species with similar habits occur to the southwestward to the Pacific coast: *C. variegatus* Drury in the South; *C. gerstæckeri* Stal. Texas and Western states; and *C. protractus* Uhl. in Utah and California.

Prionidus cristatus Linn., "wheel bug." A common species southward, recognized by the elevated toothed crest on the prothorax. While it does not enter houses, it inflicts a very painful bite which causes inflammation and may render the hand and arm useless for a number of days.

Many species in this family occur in tropical America and frequently prove troublesome, among them a species related to the "wheel-bug," which occurs in Chili and is called the "winhuka" or "rhinhuka." It is said to be greatly feared, and, if numerous, to drive people for a time from their dwellings.

Nabidæ.—These are small insects with considerable affinity to the preceding family, but slender and gener-

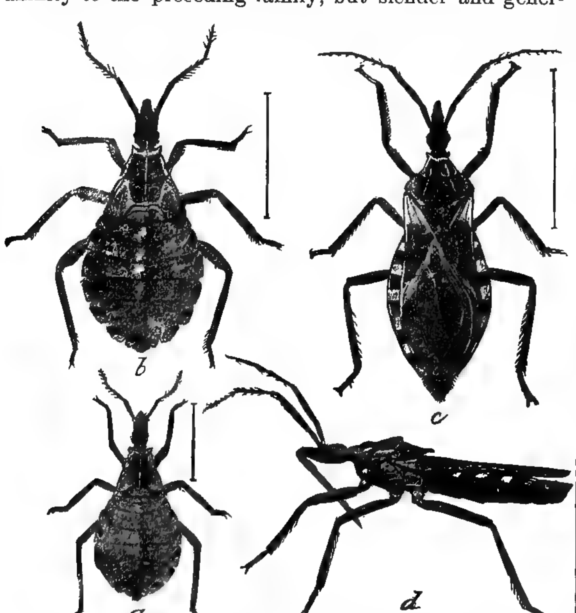

FIG. 2886.—*Conorhinus sanguisugus.* *a*, First pupal stage; *b*, second pupal stage; *c*, adult; *d*, adult lateral view. (After Marlatt, Bull. United States Dep. Ag.)

ally of dull gray or brownish color. The beak is long, rather slender, and strongly curved.

Coriscus subcoleoptratus Kby. Black or dark brown with pale legs, the body tapering anteriorly. This species is capable of inflicting a quite severe bite, and as the species is given to hiding around outhouses in wait for

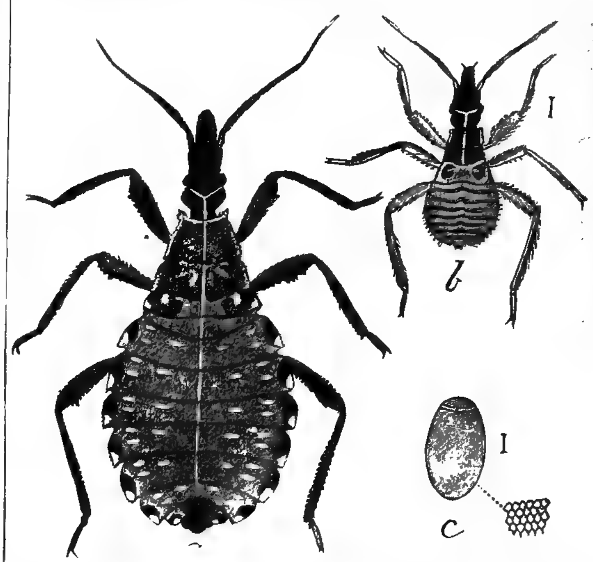

FIG. 2887.—*Conorhinus sanguisugus.* *a*, Larva second stage; *b*, newly hatched larva; *c*, egg with sculpturing at side. All enlarged. (After Marlatt, United States Dep. Ag. Bull.)

insect prey, and has been recorded as biting persons in privies, where there would be a rather favorable opportunity for it to introduce septic matter, its presence should be counted objectionable.

DIPTERA.—Insects with two wings, suctorial mouth parts, and complete transformations.

Culicidæ, mosquitoes. Mouth parts produced into slender rostrum about half as long as entire insect, slightly thickened at tip. Antennæ slender, simple in female, plumose in the male; the veins of the wings with fine scales. The larvæ are aquatic, feeding on organic matter in the water, and rising to the surface with a jerky motion in order to secure fresh supplies of air. The pupæ are also aquatic, but with respiratory tubes

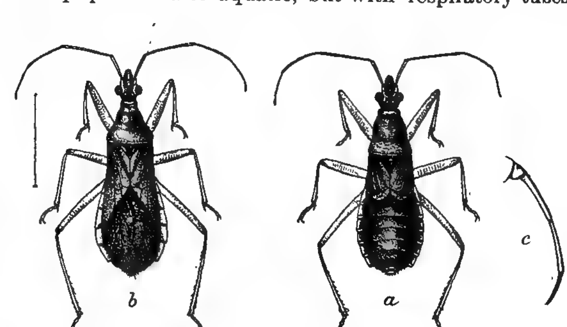

FIG. 2888.—*Coriscus subcoleoptratus.* *a*, Short-winged female; *b*, long-winged female; *c*, rostrum or beak. (After Howard, Bull. United States Dep. Ag.)

opening anteriorly instead of at end of body. The metamorphosis is complete, the pupa case splitting along the back and the insect emerging above water resting its feet on the surface; the wings expand rapidly, so that the insect takes flight very quickly after the bursting of the pupa case.

The males and females differ strikingly not only in the structure of the antennæ and mouth parts, but also in habits; the latter being the ones to suck the blood of warm-blooded animals, while the former are restricted to

fluids more easily accessible, and may very likely not feed at all in adult stage. It is recorded that they sip sweets of flowers, and even such beverages as beer and wine. It is not thought essential that the females should secure blood in order to develop the eggs, but from their great efforts to secure one or more feasts of blood it would seem to be quite an advantage to them.

The secretion of a poison which is injected into the wound has been definitely proven. The poison gland is part of the salivary gland, the salivary gland of each side being divided into three lobes, the centre one of which is different from the others, being evenly granulated and staining differently; and in this one the poison is elaborated. The secretion is carried forward, and as it passes along the duct is diluted by the secretion of the salivary lobes, and the stream then passes to the reservoir at the base of the hypopharynx. The poison is injected during the process of blood-sucking, and its purpose has been thought to be for the acceleration of the blood flow or the prevention of coagulation. One suggestion is that the mosquito is primarily a plant feeder, and that the injection of this fluid serves to prevent coagulation of all proteids, and so promote suction.

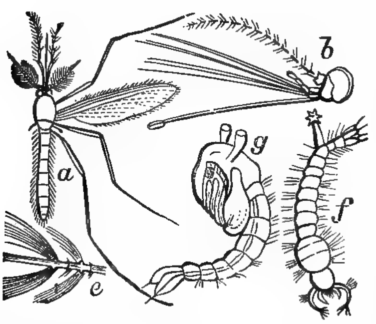

Fig. 2889.—*Culex pipiens.* *a*, Male; *b*, head of female; *e*, joints of male antennæ; *f*, larva; *g*, pupa. All enlarged. (After Westwood.)

The irritation varies greatly with different individuals, and some appear to acquire an immunity from the bites. Glycerin is recommended as giving speedy relief, and household ammonia applied as soon as possible after the bite is of service.

Culex pungens, illustrated herewith, is one of our most common species, and may be found in autumn and winter in hibernation in cellars and basements. Its rate of multiplication is extremely rapid during the summer months, the full life cycle being completed in the space of two weeks, so that numerous broods occur during a season.

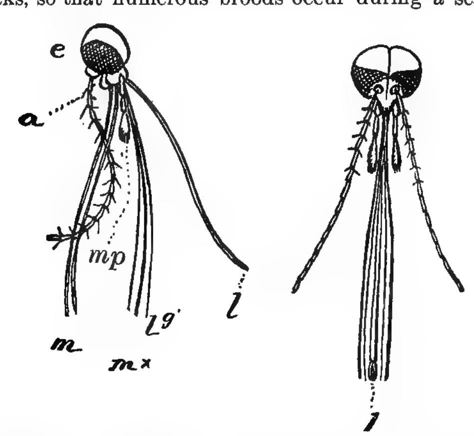

Fig. 2890.—Mouth Parts of Female Mosquito; Front and Side View. *a*, antennæ; *mx*, maxillæ; *mp*, maxillary palpi; *m*, mandible; *l*, labrum; *e*, eyes. (After Packard.)

The eggs are placed in large, boat-shaped masses and the larvæ develop rapidly. Their characteristic position in getting air at the surface is shown, and may be contrasted with that of the larva of *Anopheles.*

Other species of Culex which are common in the United States are *tæniatus, tæniorhynchus, consobrinus, stimulans, excitans, impiger*, etc., at least fourteen of this genus being credited to our fauna.

Anopheles maculipennis Meig. This species has more slender body and longer legs than *Culex pungens*; the wings are marked with dusky patches; the scales of the last vein are black and the palpi entirely black. The eggs in this form, instead of being deposited in boat-shaped masses, are laid singly and float on the surface of water till hatching. The larvæ have a much shorter respiratory tube, and when taking air rest with the head held close to the surface as shown in the figure.

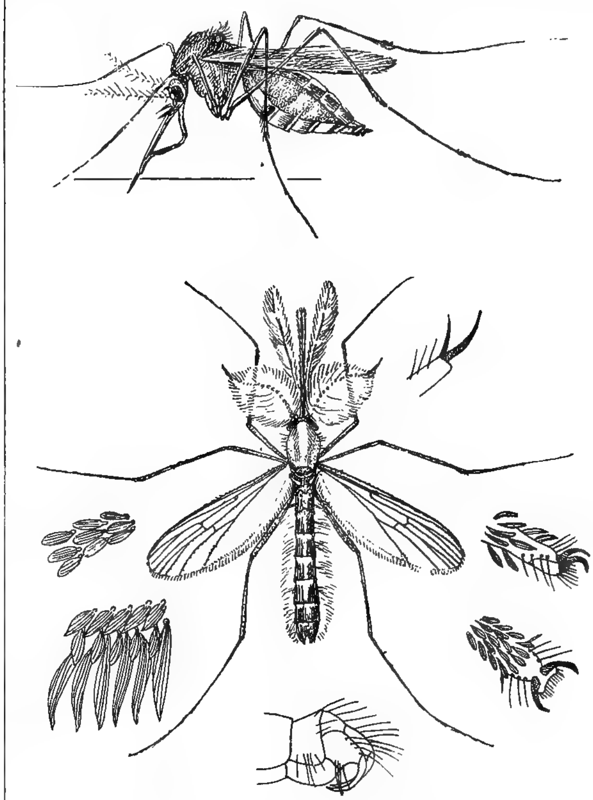

Fig. 2891.—*Culex pungens.* Female above, male below. Enlarged. (After Howard, Bull. United States Dep. Ag.)

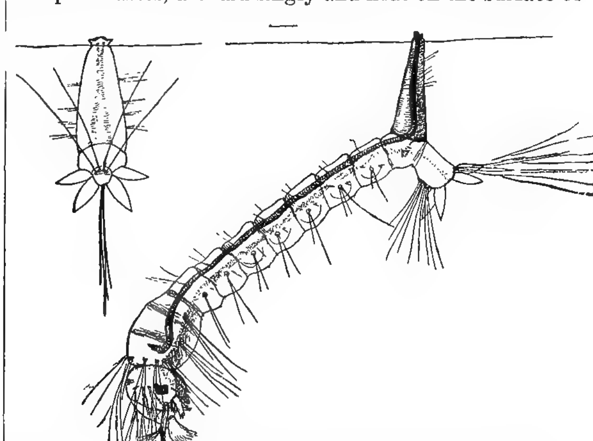

Fig. 2892.—*Culex pungens.* Larva in breathing position at surface of water. (After Howard, Bull. United States Dep. Ag.)

The adult mosquitoes of *Anopheles* assume, when resting on wall or ceiling, positions different from those as-

sumed by *Culex*, a point which may be used in separating the members of the two genera; the body is held with the

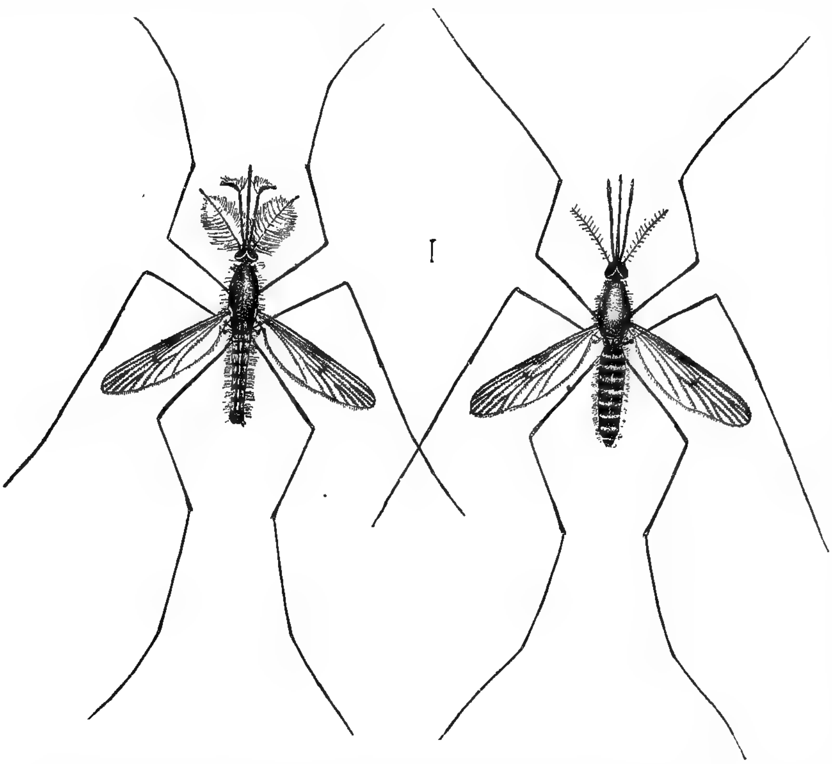

FIG. 2893.—*Anopheles maculipennis* Meig. Male at left, female at right. (After Howard, Bull. United States Dep. Ag.)

proboscis, thorax, and abdomen all in one line, while in *Culex* there is a distinct bend or humpbacked appearance. Generally only four legs are used in holding to the surface, the hind pair being raised in the air; or, if the mosquito is hanging to a ceiling, they swing loose below.

Structurally *Anopheles* may be separated from *Culex* by the length of the palpi, which in both sexes are at least almost as long as the proboscis, while in *Culex* the palpi are in the female less than half as long as the proboscis, in the male nearly as long.

The species of this genus have a special interest as carriers of the malarial plasmodium. (See *Mosquito in Relation to Human Pathology*.)

Simulidæ, black-flies, buffalo gnats. Antennæ eleven-

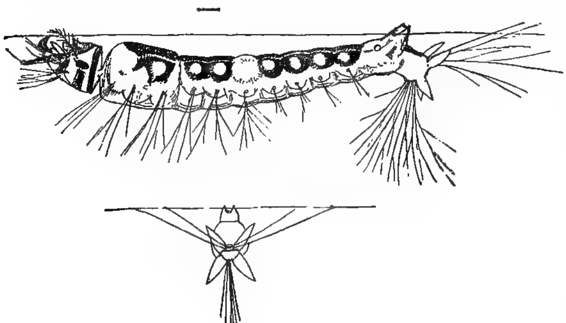

FIG. 2894.—*Anopheles maculipennis* Meig. Larva showing breathing position at surface of water. (After Howard, Bull. United States Dep. Ag.)

jointed; mouth parts fully developed, fitted for piercing; no ocelli; larvæ and pupæ aquatic; metamorphosis complete. These insects are terrible torments in different parts of the world, the most famous being the Columbacz midge of the Danube valley, the black fly of the North-eastern United States and Canada and the Southern buffalo gnat of the Mississippi valley. Not only is their bite most painful, but a poison is injected which causes a severe swelling and produces, when many bites are aggregated, an effect of blood poisoning which is fatal to many animals, and numerous instances are recorded of serious effects on man, or even of fatalities, though these are less numerous doubtless because of the better protection which can be given to sensitive parts. The buffalo gnat, which has been studied very exhaustively by the United States Division of Entomology, illustrates very well the habits of the different species.

Simulium invenustum Walk. =*pecuarum* Riley. Perhaps the best known of the species and called buffalo gnat or Southern buffalo gnat. One of the largest species, 2 to 4 mm. long, thorax largely blackish, abdomen of female grayish-brown or black, the sides marked with a row of velvet black spots. These gnats occur in vast swarms which in the lower Mississippi valley appear in early spring and range over a wide stretch of territory, being driven by the wind so that they may cause serious injury at long distances from their breeding grounds. Only the females have the mouth parts developed for biting, and it is said that many so gorge themselves with blood as to render themselves helpless so that they do not succeed in depositing eggs. The shade of buildings seems to be the only effective safeguard, but smudges and the application of fish oil or other repellent substances is of some advantage. The life history is quite peculiar, the larvæ being elongate, legless creatures with peculiar fan-like processes on the head end which keep up a constant motion, thus creating currents of water and bringing food materials within reach, as well as providing for the respiration. They are anchored by a silken thread and attach themselves where they get the swiftest currents in the creeks or bayous of the region where they breed. The pupæ are formed within a silken cradle-like cocoon, open at one end, from which the head portion of

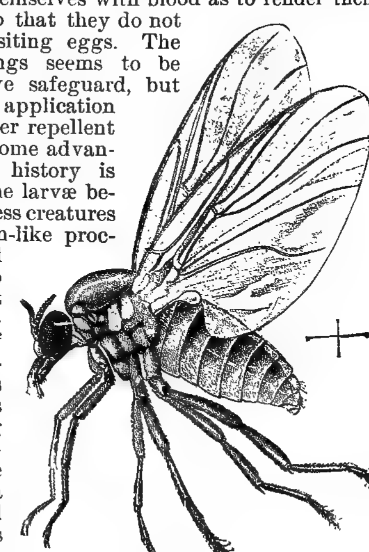

FIG. 2895.—*Simulium invenustum*. Adult female. (After Riley, Rept. United States Dep. Ag.)

the pupa projects. From the anterior portion of the body projects a cluster of hair-like respiratory filaments, forty-eight combining into a trunk-like portion at base which communicates with the tracheal system within the body. The eggs are laid close to the edge of the water on convenient objects, often where the water dashes over them so that the larvæ on hatching are carried at once into the water.

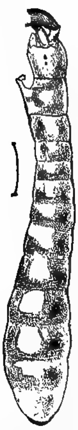

FIG. 2896.—*Simulium invenustum.* Larva. (After Riley.)

Tabanidæ, gad-flies, breeze-flies, or horse-flies. Mouth parts well developed, fitted for piercing; those of the female more powerful than those of the males, which latter do not attack animals. In the female there are six exserted lancet-like parts, in the male but four. Proboscis ends in two fleshy lip-like lobes and is covered on the sides by the large two-jointed maxillary palpi. The eyes are very large, especially in the males, often beautifully colored and iridescent.

There are an enormous number of species in this family distributed over the globe, and a large number occur in the United States where they are a great torment to different animals and often to man by their severe bites. The larvæ, so far as known, are aquatic or subaquatic and carnivorous so that they are to be considered rather innoxious or even beneficial as related to man. The bites, though not strictly poisonous, are extremely annoying, and may cause such irritation as to be of importance. They are apt to be most troublesome in the vicinity of water, and may almost prohibit boating or bathing in certain localities. It is often stated that horses and cattle are killed by their persistent attacks, but such cases must be rather rare.

FIG. 2897.—*Simulium invenustum.* Pupa. (After Riley.)

Tabanus atratus, black breeze-fly. This is one of our largest species and a very troublesome one to cattle, but it seldom attacks man or horses. It is black with a bluish-white bloom on the surface of the abdomen and the wings are a smoky brown. The larva is a large twelve-jointed, cylindrical worm, tapering at each end, of a transparent, polished, glassy, yellowish or greenish appearance, with large roundish, retractile tubercles. It is found in water or sometimes in rotten wood or among floating débris where it appears to get its food. Among other things it appears to feed commonly on mollusks.

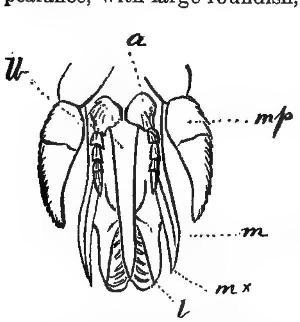

FIG. 2898.—Mouth Parts of *Tabanus*. *lb*, labrum; *m*, mandibles; *mx*, maxillæ; *mp*, maxillary palpi; *a*, basal joint of antennæ; *l*, tongue. (From *American Naturalist*.)

As the horse-flies frequent pools and doubtless resort to them to drink as well as when depositing eggs it has been found that placing a little kerosene on the water serves to destroy large numbers of them and thus not only cut short their career but reduce the numbers for later generations.

Coleoptera, beetles. Insects in which the fore wings are hard, horny, or leathery and serving as protecting covers for the hind wings which are membranous and the organs of flight. The larvæ are various, some with well-developed legs, others footless grubs. Transformations complete.

The ground beetles (*Carabidæ*) have in some species the power of secreting a poisonous or acrid fluid effective

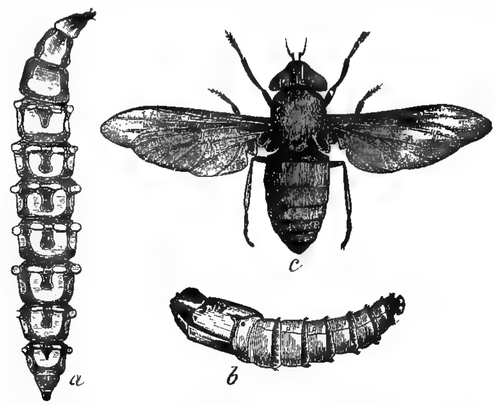

FIG. 2899.—*Tabanus atratus.* *a*, Larva; *b*, pupa; *c*, imago. (After Riley.)

against small animals, but no more than repugnant to man. The Bombardier beetles discharge their secretion with a sharp report, and the cloud of vapor (which reaches some inches) has a strong pungent odor and when condensed becomes a yellowish fluid with a strong acid reaction.

The distinctly poisonous forms are included in the family *Meloidæ*, which includes our blister beetles. There are several native species which possess the vesicating property, among them the *Macrobasis unicolor*, *Epicauta vittata*, *Epicauta cinerea*, and *Epicauta pennsylvanica*. The blisters which they cause, if their vesicating fluid is inadvertently rubbed on the face or hands, may prove quite

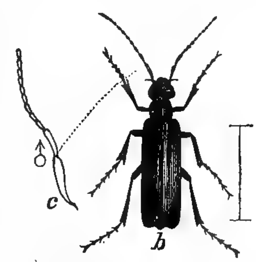

FIG. 2900.—*Macrobasis unicolor.* Line, natural size; *b*, beetle; *c*, enlarged male antenna. (After Riley.)

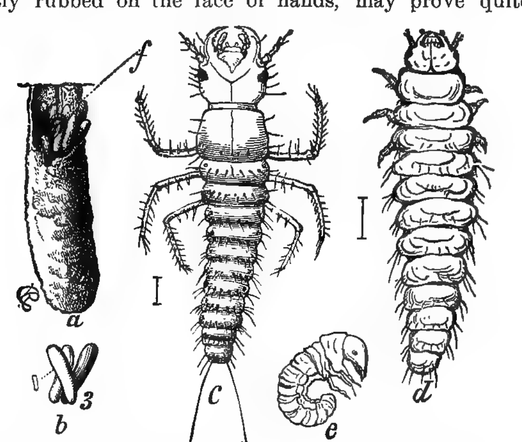

FIG. 2901.—*a*, Egg pod of *Melanoplus differentialis*, with the mouth torn open, exposing the newly hatched larva of *Epicauta vittata* eating into an egg. Natural size. *b*, Eggs of *E. vittata* the natural size indicated at side; *c*, dorsal view of first larva or triungulin of *E. vittata*; *d*, dorsal view of second larva of *E. vittata*; *e*, side view of the second larva, showing its natural position within the locust-egg mass. (After Riley.)

distressing, though the effect depends somewhat on the condition of the skin, being much worse if the pores are open and perspiration is free. The early stage of

these insects is very interesting and shows very strikingly that an insect that is troublesome or destructive in one stage may be very serviceable in another. Riley has shown that the larvæ feed upon the egg masses of grasshoppers in the ground, where the eggs are laid by the

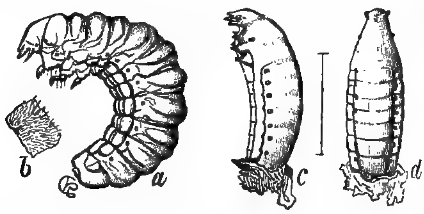

FIG. 2902.—*a*, Lateral view of the ultimate or full-grown stage of the second larva of *E. vittata;* *b*, portion of the dorsal skin showing short setaceous hairs; *c*, lateral view of the pseudo-pupa or coarctate larva of *E. vittata*, with the partially shed skin adhering behind; *d*, dorsal view of the same. (After Riley.)

adult beetles; furthermore, that there is a distinct hypermetamorphosis. The egg hatches into a carabid-like larva with legs and active habit, and this form proceeds to search out the locust eggs and feed upon them and at its first moult changes its form to become much thicker; and after another period of feeding it moults again, changing this time to a still thicker form and having the mouth parts and legs become atrophied. After still another period it moults again with little change except in size, and finally after another period it forsakes the egg mass and burrows into the soil to assume the pupa stage. The changes here sketched most briefly are shown very fully in the accompanying figures.

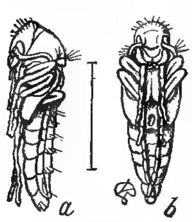

FIG. 2903. — *a*, Lateral view of true pupa of *Epicauta cinerea;* *b*, ventral view of same. (After Riley.)

Cantharis vesicatoria L., Spanish fly. This is the best known species from the medical standpoint, being an official species the basis of the *cantharidin*, which has a quite general use in practice. The insect occurs everywhere in the temperate regions of Europe.

The vesicant property is due to a peculiar volatile, crystalline chemical principle, *cantharidin*, which is very soluble in alcohol, ether, or essential oils. Externally it produces blisters and internally it is a violent irritant poison. It is said that gr. $\frac{1}{100}$ on the lip will rapidly cause a blister. Its use is mainly as a topical application in cases of indolent ulcers or as an excitant.

Mylabris cichorii, the "Telini fly" of India, possesses

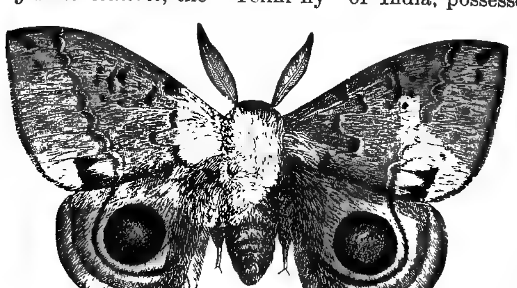

FIG. 2904.—*Automeris io.* Male moth. Natural size. (After Riley.)

also very strong vesicating properties equal to or greater than those of the preceding species.

Lepidoptera, moths and butterflies. Wings four in number and covered with minute imbricated scales, appearing as fine dust; mouth parts developed into long suctorial tube for feeding upon the nectar of flowers, though in some cases rudimentary, and the adults not feeding. A complete and striking metamorphosis, the early stages being called caterpillar and chrysalis for larva and pupa. None of these insects is poisonous in the adult stage, but a few have larvæ that possess urticating properties, or that poison or irritate the skin either from the presence of a poisonous fluid or the breaking off

FIG. 2905.—*Automeris io.* Female. (After Riley.)

of minute spines. Some which are popularly supposed to be poisonous are perfectly harmless, as is the case with the large tomato worm *Phlegethontius celeus.*

The species which possess injurious properties belong mainly to a few families of the night-flying Lepidoptera, and include some of our very common species.

Automeris io, Io moth. A very handsome moth, the male considerably smaller than the female, brighter colored, deep yellow marked with purple brown, the body and the hind wings being of a deep ochre color; the antennæ are large, plumose. The female is darker with predominance of purple, the markings on the front wings somewhat differently arranged. The cream white eggs have a small black spot on the apical end. They are laid on leaves of various plants, the insect having a wide range of food plants, such as willow, corn, cotton, hops, clover, elm, cherry, etc. The larvæ are of a green color, and when full grown have longitudinal stripes on the sides of white and lilac red. The spines arise in clusters from papillæ and have various shapes, some with few and others with many tips. The spines are evidently connected with glands which secrete the urticating fluid, and when broken off in the skin produce an intense nettling sensation. Aside from the spines the io

FIG. 2906.—*Automeris io.* Larva. Natural size. (After Riley.)

caterpillar possesses eversible organs on the fourth and tenth segments which probably serve to drive off some of their enemies, but they do not appear to have anything to do with the urticating property.

Hemileuca maia Drury, buck moth. Another handsome moth the larva of which possesses urticating spines, but less severe in their action than those of the Io. The larvæ are brownish-black, covered with more or less conspicuous small, oval, yellow protuberances, with a lateral yellow stripe made up of papillæ and broken, irregular yellow marks.

Empretia stimulea Cl., "saddle back." A brown caterpillar with a very distinctive saddle-shaped green spot on the back. The poisonous spines are set on large processes at anterior and posterior ends and along the sides. Here probably the poison is secreted in the larger processes and fills the small spines so that when they are broken off in the skin they cause the smarting sensation. The moth is of a rich brown color but not so striking in appearance as the larva. The larva occurs on a variety of plants, such as corn, cotton, and various trees and shrubs, but fortunately is not a very abundant species. It is also conspicuous enough to attract attention and hence less likely to be brought in contact with the hand.

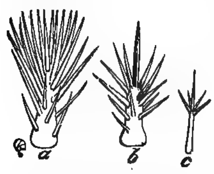

FIG. 2907.—*Automeris io.* Poisonous spines. Enlarged. (After Riley.)

Lagoa crispata opercularis Harr. is another urticating species, the poisonous spines being hidden beneath a clothing of long hairs. In the tropics are a number of related species which are much feared by the natives.

In Europe the processionary caterpillars, *Cnethocampa processionea*, are counted objectionable on account of the urticating properties of a farinaceous substance derived from drying of an acrid secretion from the entire surface of the body. It is particularly irritating on contact and especially on delicate mucous surfaces as in the air passages. Workmen in forests where the caterpillars are plentiful are reported to sicken rapidly from this cause. "The long hairs under the microscope are seen to be branched, and are said to be filled with formic acid. When broken off in the human skin, they produce a terrible itching and burning sensation. There are many cases on record in which such hairs have found their way by some means to the interior organs of people and animals, producing dangerous inflammation, resulting even in death." Certain Brazilian species are reported to be even more distressing in the effects produced on the human skin. Ammonia may be used to relieve the irritation.

Hymenoptera, bees, wasps, ants. Four membranous wings, the hinder ones the smaller; mouth parts adapted for either biting or sucking; the body regions sharply marked; the abdomen connected to the thorax, in most forms, by a slender pedicel. This group includes very poisonous and aggressive species provided with a sharp sting, in a large portion of the group, from which a distinct poison is discharged. Even in the *Terebrantia*, in which the sting is not so specially developed, there are some species, as in *Ophion* and other ichneumonids, which may pierce the skin with the ovipositor, giving a quick, sharp sting that is momentarily very painful but seldom of any lasting effect. In the *Aculeata*, or true stinging forms, there is an elaborate sting modified from the ovipositor, and hence present only in the females, through which the secretion of large poison glands is discharged. Carlet found the poison glands of the bee to consist of two kinds, one secreting a feebly alkaline fluid, and the other an acid product. The poison is effective only when the two are mixed. In those which poison with the sting both kinds of glands are well developed; while in those forms which paralyze their victims to preserve them as food for their larvæ, the alkaline glands are vestigial. In ants, wasps, and bees there are two substances, according to Will, viz., formic acid and a bitter fatty residue, the formic acid being the essential part of the poison. In some ants the sting is wanting, but the poison glands are extraordinarily developed.

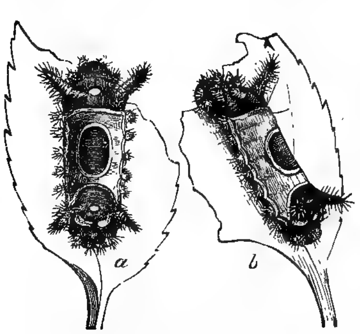

FIG. 2908.—*Empretia stimulea.* Natural size. (After Riley.)

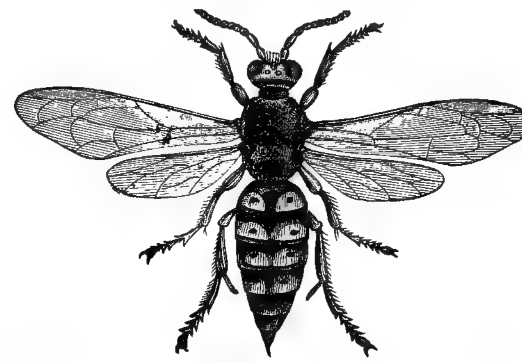

FIG. 2909.—*Sphecius speciosus.* Giant digger. (After Riley.)

Formicidæ, ants. The ants usually seen are the wingless workers which are noticeable for their large heads and jaws, and their sharply separated abdomen. The males and females are winged, but the latter lose the wings after being fertilized and taking up their duties as the mother of a colony. The workers which are undeveloped females have, like the queens, a sting, and in some forms it is used with severity upon any disturber. In other species the bite is poisonous, being accompanied with an injection of formic acid. The colonies when disturbed attack the intruder with great fury, and some of the larger species inflict such serious wounds that death is said to result from their attacks.

Mutillidæ, "velvet ants," "cow-killers." Brightly colored ant-like insects with a dense covering of hair giving them a velvety appearance. The body is exceedingly hard, very difficult to crush, and the sting is quite severe. They occur particularly in open and sandy places and seldom sting unless caught.

Fossores, digger wasps. This group includes a large number of our common wasps, among them some of the most poisonous we have. While as a rule inclined to attend strictly to their own affairs and not to sting except on provocation, they will sometimes make unprovoked attacks. They agree in constructing nests in the ground, are mostly strong-bodied, and capture other insects or spiders with which to provision the nests for their young. The stings they inflict on these victims are directed to the nerve centres and serve to paralyze but not to kill, so that they are kept fresh but helpless till such time as the young hatch and are ready to feed upon them.

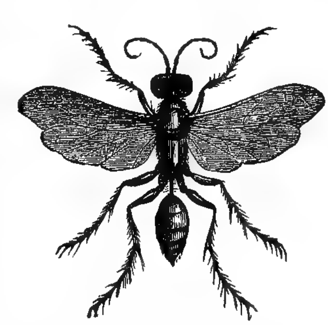

FIG. 2910.—*Chlorion cœrulium.* Blue digger wasp. (After Riley.)

Sphecius speciosus Drury. This is one of the largest species, and a common insect in the Central and Southern States. It provisions its nests with Cicadas, which are frequently much larger than itself. Its sting is very

severe, and Riley states that two or more inflicted on a man at one time might easily endanger his life. It may certainly be counted as dangerous as the scorpion and ought never to be provoked to try its power.

Chlorion cærulium Drury. A handsome blue species with dusky wings. It occurs very frequently around

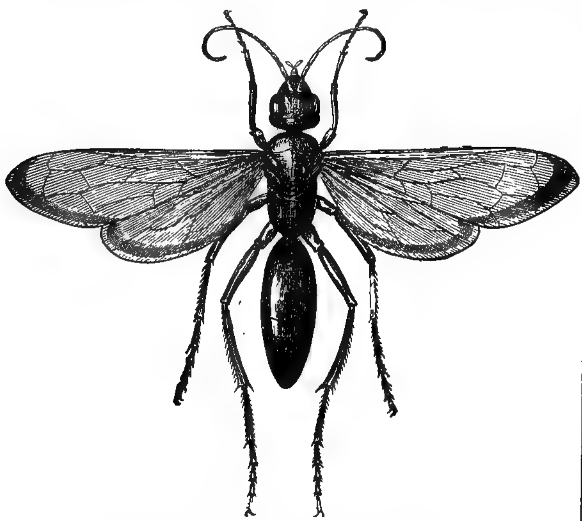

FIG. 2911.—*Pepsis formosa*. (After Riley.)

houses, seeking spiders which it captures, stings, and stores away in its nest for its young. Its sting, while not so severe as that of the preceding species, is by no means to be despised, and since it is a more frequent visitor in houses it is more likely to be incited to attack.

Sphex ichneumonea L. is a large species with brilliant golden markings. It frequents flowers and captures meadow katydids to store in its nests which are placed in gravelly walks or along roadsides where the ground is very hard.

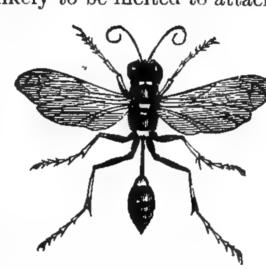

FIG. 2912. — *Pelopœus cementarius*. (After Riley.)

Sphex pennsylvanica L. is another common species equalling the preceding in size, but of a brilliant blue-black color.

Pepsis formosa Say, "tarantula killer." A gigantic species, which occurs in the Southwestern part of the United States, where it is counted serviceable on account of its killing tarantulas, with which it provisions its nests. Its sting is very poisonous.

Pelopœus cementarius Drury, "mud dauber." A dark species, with yellow lunate spots and with a very slender petiole supporting a small abdomen. This species is very frequently noticed in houses, in attics, or even in much-used rooms, where it can gain access through some crack, and in barns, sheds, and tents. Its nest is constructed from pellets of mud, and the cells each containing a larva are stored with small spiders. They seldom molest people, even when passing very near them to reach the nest, but sting severely if provoked, and their presence is in itself annoying on account of the fear. There are many related species, some of which also build nests in houses.

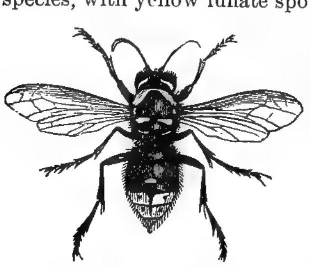

FIG. 2913.—*Vespa maculata*. (After Riley.)

Vespidæ, paper wasps. Wings folding longitudinally when at rest; bodies rather robust, the abdomen attached by a short pedicel. All the species sting viciously when disturbed, and do not always wait for any serious provocation. Two species may serve as examples of the group.

Vespa maculata L., bald-faced hornet. A heavy-bodied species with light yellow, almost white face, and yellow spots on the thorax and abdomen. The large nest is built by degrees of a strong gray paper and contains, when fully formed, a number of combs one above another all enclosed within the large outer case. The

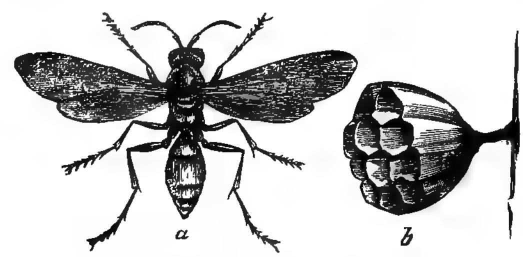

FIG. 2914.—*Polistes*. (After Riley.)

opening is at the lowest point and the whole nest is hung by a stout cord to a branch of a tree or the under side of a fence rail or other suitable support. If disturbed these hornets make a fierce attack on the intruder and a number of stings will cause pretty serious symptoms in the victim. Applications of ammonia, glycerin, bicarbonate of soda if made promptly will much relieve the swelling and inflammation.

The "yellow jackets," *Vespa vulgaris* L. and *V. germanica* F., are smaller, but similar in habit, and fully as vicious.

Polistes pallipes St. Farg. The more slender species included here also build paper nests, but only a single comb and this without any outer case; so the growing larvæ may be easily seen by any one with sufficient nerve carefully to inspect the nest. They are frequently built in houses in window frames and the wasps may become troublesome as the number increases and they grow irritable.

Apidæ, bees. Robust, usually hairy, the mouth parts with a long tongue adapted to lapping the nectar from flowers. This family includes the bumble bees and the honey bee as well as a large number of species less familiar. The sting is like that of the other *Aculeata*, and that of the honey bee may be noted as an example of the others. The principal parts are the three pieces of the normal ovipositor, the centre one of which constitutes a sharp lancet-like instrument. At its base is the large poison reservoir fed by the poison gland.

FIG. 2915.—Sting of Bee. Enlarged. *a*, Tip of lancet, still more enlarged. (After Gosse.)

Xylocopa virginica Drury, "carpenter bee." This species very much resembles a bumble bee, but has the abdomen polished and without hair. They bore into wood to construct nests and so may prove troublesome around houses, as their sting is very painful.

Bombus sps. The common bumble bees are very familiar objects, several different species occurring in almost any locality. They build nests in holes in the ground or, rarely, in deserted bird nests or other places at some distance above ground.

Apis mellifica, honey bee. The domesticated bee

now represented by several varieties. They are the most frequent source of stings since they are so commonly kept in the vicinity of houses. The sting affects different persons very differently, some suffering intensely from a single sting, while others suffer no inconvenience, after the temporary pain, from a number of stings. Inflammation, rapidly extending from a sting on the hand even so far as the length of the arm, and sometimes so as to close the eyes, may follow. Prompt application of ammonia, bicarbonate of soda, or even of moist clay will serve to give relief. *Herbert Osborn.*

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INSOLATION. See *Heat-Stroke.*

INSOMNIA is defined as the loss of the normal amount of sleep, and this involves a recognition of the fact that with different individuals different amounts of sleep constitute what is normal to each. Absolute loss of sleep is of much less frequent occurrence than the statements of patients would indicate. When such is the case, it is a *symptom* of serious import, and the statement impresses upon one the fact that as the absolute so also the minor degrees of this abnormality are to be regarded as symptoms. Often they are of great significance, but still rather as indications of the existence of morbid states, which it therefore becomes the duty of the practitioner to look for and treat, than as in themselves diseases which demand the direct application of remedies. In other words, the physician should not feel that he has done his duty by his patient in simply prescribing hypnotic drugs, though this may often be all the sufferer expects, but should search out the causes which underlie this symptom and endeavor to remove them and incidentally this one of their results. Of course there are many cases coming under our attention in which the chief object of treatment is the relief of the insomnia, in which, the habit of sleeplessness once broken up, we may expect the bodily functions to be restored and strength recovered; but he will probably achieve the best results who endeavors to ascertain the causes leading to the loss of sleep in each instance and to base his therapeutics upon a classification of such causes.

Recognizing that sleep is a normal and healthy function, it is quite in accord with the best traditions of medical science to endeavor to understand its mechanism and relation to other vital phenomena as a foundation for the study of its abnormalities; in other words, to make physiology the guide to pathology. It has proved, however, to be a difficult problem, and no conclusion seems to have been reached which is accepted as wholly satisfactory. The following statement by Professor Howells is an expression of recent views of an acknowledged authority. "We might therefore say that three factors combine to produce normal sleep. I. A diminution of irritability, caused by fatigue, of large portions of the cortical area. II. Voluntary withdrawal of sensory and mental stimuli involved in the preparations for sleep. III. A diminished blood supply to the brain, owing to a relaxation of tone in the vaso-motor centre and the fall of general arterial pressure thereby produced. The last factor is the immediate cause of sleep and explains its comparatively sudden and nearly simultaneous occurrence over the entire cortex."

As a foundation for a theory of therapeutics applied to insomnia, the view of a diminished blood supply to the brain as a feature of normal sleep has been very attractive, and many attempts have been made to explain the action of well-known hypnotics or to base new methods of combating the trouble upon the accepted or supposed action of such remedies in increasing or diminishing the blood supply of the brain. Such efforts have contributed to an intelligent study of the causes of insomnia, and analysis of the reasons why certain remedies succeed in certain cases, but have sometimes been less successful than their authors have expected, because the theories of the physiological causes of sleep have not been fully established (Granville, R. Ferguson). The former author adduces Bichat's view that general or complete sleep is the sum of the special sleeps or dormant states of the various faculties or senses, while Ferguson contends that hyperæmia is sometimes accompanied by sleep, which to be sure may not be very good, and likewise that anæmia leads to a sleep just as far from normal. Their arguments are against the routine use of soporifics. Insomnia as a symptom most constantly presenting itself for treatment, independently of medication demanded by the patient's other requirements, probably comes up most frequently before those whose practice is among the insane and patients with affections of the nervous system. It will be well to keep this in mind, in considering the classification of causes of insomnia, and their indications for treatment, for the general practitioner will find quite a different class of causes predominant in his daily experience from those met with by the asylum specialist.

A few words should be said on the results of insomnia. Manaceïne, for example, ascribes to the injurious effects of imperfect and broken sleep the interruption of the nutrition of the tissues. Duval says insomnia leads to emaciation and debility, and in sickness, when prolonged, is an unfavorable sign. Bulkley tells us of eczema appearing as a result of long-continued loss of sleep. These statements are of course quite apart from what might be said of insomnia as a precursor of insanity or cerebral disease.

Most writers on this subject give a grouping of the causes they recognize as predisposing to or directly inducing insomnia. Thus Tuke ranks among the predisposing causes the female sex, old age, nervous temperament, intellectual pursuits; while among exciting causes he mentions organic or functional diseases of the brain, worry, anxiety, grief and bodily pain, noise if not monotonous, fever, coffee, tea, etc. Sanger Brown divides insomnia into functional, symptomatic, and that of insanity, and states that neurasthenia is often sooner or later associated with the first of these. He also quotes Folsom as specifying the following causes or conditions of insomnia, viz.: habit, such reflex causes as indigestion and genito urinary disorders, autotoxic causes, such as gout, lithæmia, syphilis, habitual constipation; then anæmia, vaso-motor changes, neurasthenia, hallucinations of sight or hearing, astigmatism, and the neurotic temperament. These brief quotations indicate in how many ways this question of etiology presents itself to different trained minds. Among them I find no more comprehensive and simple classification than that of Professor Bradbury in Allbutt's "System of Medicine." I cannot give it *in extenso*, but the following are its chief features: First, *Irritative Causes*, such as are due to pain and like uneasiness, comprising such various ones as teething in children, eye-strain, the irritation of an eczema, the discomforts often following a surgical operation, even when pain is absent, various affections of the respiratory organs, especially when accompanied by cough, acute inflammations of the serous membranes, many tumors and surgical diseases. Insomnia from many of these may involve other etiological factors, but *pain* is the predominant one and that which necessitates treatment.

Second, *Toxic Causes.* In many diseases a toxic agent is present in the blood. Such are alcoholism, the exanthemata, most of the zymotic diseases, dyspepsia and intestinal disorders, gout, Bright's disease. To these he adds, under this heading, heart disease and altered vascular conditions, though in them the insomnia may be

partly due to altered heart action and partly to a deficient blood supply. Certain drug habits, such as opium-eating and cocaïnism, also are included in this class.

Third, *Psychical Causes.* A nervous temperament, neurasthenia, hysteria, or hypochondriasis, often acts as a predisposing factor leading to a habit of insomnia. Grief, shock, worry, and mental anxiety are very frequent causes. The insomnia which occurs at the menopause is attributed partly to the accumulation in the blood of toxic products not eliminated by the catamenia. In cases of insanity, insomnia often appears both as a premonitory symptom and as a feature of the disease, also as a factor leading to its occurrence.

Fourth, *Causes Arising from Change in the Mode of Life.* Among the most noticeable in this class are changes in the time of the principal meal, changes in climate, especially to high altitudes, and such changes of occupation as nurses are liable to, from night to day duty.

Such considerations as the foregoing must be our guides in deciding upon treatment. The dermatologist, the pædiatrist, the surgeon, no less than the alienist, becomes familiar with those causes of insomnia which arise in his own specialty. The general practitioner must scan the whole field. In many instances, especially in acute disease accompanied by pain or fever, the treatment called for by the general requirements of the case will relieve the incidental insomnia without separate prescriptions for it. In fact the rule would be, in cases classed as symptomatic, to treat the main disease. A second most important principle of treatment is urged by C. K. Clarke when he says that drugs should be our last resort, after exhausting all accessory remedial agencies such as come under the head of hygiene, including matters of food and drink, exercise, bathing, ventilation, and habits of work. Sanger Brown also reminds us that drugs that abolish consciousness are not necessarily hypnotics. Still there is no safer rule for our guidance, especially in the irritative class, when pain is present, than to address our treatment primarily to its relief, and it is because opium in one form or another is still our great reliance as an anodyne that it is still considered a soporific, although its action is to engorge rather than unload the blood-vessels of the brain, and so far to antagonize the normal conditions of sleep.

Lack of space would forbid our taking up for detailed consideration all the therapeutic agencies to procure sleep, and there is the less need to do so inasmuch as they are mostly familiar remedies, with the exception of the more recently discovered chemical hypnotics, which still demand further impartial trial before they can be permanently classed. We must, therefore, refer our readers to the larger special essays on this subject, particularly to those of C. K. Clarke, E. P. Hurd, Sanger Brown, and Bradbury, in which full particulars are given. To these we may well add a few points which enforce the principles of treatment already enunciated and are of direct practical value.

As to electricity, Eskridge and Sanger Brown agree that its efficacy as a hypnotic is doubtful, but if used it should be in the form of a galvanic current of from 2 to 5 milliampères, which may be passed through the head for ten minutes or more, a large electrode being placed behind the ear. Trional has been so generally used, and with such confidence in its safety that we may make the following citations: R. Ferguson recommends that it be reserved for use in cases in which sleep may be well begun, but is liable to be broken off before the end of the night. It may be given at any time during the night, because its action is so prompt, as compared with that of sulphonal. Sanger Brown says that trional is not always safe even in small doses, which caution is enforced by a case reported by E. M. Thompson and by other reports published during the past year.

Discussing the management of insomnia in cardiac failure Alexander Morison says that we must attack the most evident cause in each case and then give the chosen drug in adequate doses. He values sulphonal most in cases in which emotional excitement is a prominent cause, and next to that opium, but sleep must be had.

As pointing to "the importance of anæmia of the brain for molecular inactivity and sleep," Fox claims almost certain success for the use of a long, narrow sinapism down the whole length of the spine; and the efficacy of Clarke's recommendation of a bath for twenty minutes at 104° F., with perhaps cold to the head in the insomnia of mania, evidently depends on the same principle. In addition to the works quoted, my readers will be glad to have their attention directed to the little volume of M. de Manaceïne, with its research into the physiology and pathology of sleep and a very extensive bibliography.

J. Haven Emerson.

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INTERCOSTAL NEURALGIA. See *Neuralgia.*

INTERMITTENT FEVER. See *Malarial Diseases.*

INTERTRIGO. See *Eczema.*

INTESTIN, bismuth naphtalin benzoate, is an intestinal antiseptic and astringent, which is given in dose of 0.5 to 1 gm. (gr. viij.–xv.) for dysentery, diarrhœa, and intestinal putrefaction.

W. A. Bastedo.

INTESTINAL MOVEMENTS.—The movements of the muscular walls of the intestine have a twofold purpose, since they serve in the first place to propel the food along as the processes of digestion and absorption take place and also aid those processes by intimately mixing the food with the digestive juices, and by bringing continually fresh portions in contact with the absorbing wall.

The muscular wall of the intestine is formed by two distinct coats separated by a thin layer of connective tissue in which ramifies the plexus of Auerbach, consisting of small ganglionated nodules of cells, from which pass strands of non-medullated nerve fibres, uniting the various ganglionated masses, and sending off terminal networks which ramify around the muscle fibres. The cells of the inner muscular coat are arranged circularly around the tube of the intestine, while those of the outer coat are arranged longitudinally, and there has been much dispute as to whether these contract synchronously or alternately. It appears most probable, however, from recent observations of Bayliss and Starling, that simultaneous contraction is the rule, and that the longitudinal fibres simply aid the circular fibres in evoking contraction of the lumen of the tube.

Two distinct types of movement occur in the intestine, namely, the true peristaltic wave of contraction, and the swaying or pendular movements, which are identical in rhythm with contractions of the wall taking place at a much more frequent rate than those concerned with true peristalsis. In addition to these a very pronounced and much more rapidly progressive wave has been observed under certain circumstances, such as exposure of the gut to cold, anæmia of the intestine, or presence of gaseous contents, to which the name of *vermicular* contraction has been given. Mall considers this a distinct type of intestinal wave, but according to Bayliss and Starling it is but a pathologically intensified form of that type of contraction which causes both the pendular movements and ordinary rhythmical contraction.

The velocity of the true peristaltic wave, of which the chief function is to move the food onward in the intestine, is very low, amounting only to about 2 cm. per second; so that in the cat it has been estimated that it would require about an hour and a half for this form of wave to travel from one end to the other of the intestine. The rate of progress is very regular, and, when the local nervous mechanism represented by Auerbach's plexus is in action, it passes only from above downward. But after the nerve cells of this plexus have been paralyzed by nicotine or cocaine, the contractions which are then purely myogenic pass equally, from a point directly stimulated, in either direction up or down the tube. This change in character after paralysis of the local nerve centres demonstrates that the normal true peristaltic wave is a local reflex, and the same, it is stated, can also be shown for the other more rapid type of rhythmical contraction which is connected with the pendular movements.

Mall has shown that the local reflex consists of a relaxation of the wall in front of the advancing wave in addition to the localized constriction which travels down the tube, and Bayliss and Starling, who have recently investigated the subject, confirm this view, and style this combination of a contraction wave preceded by a wave of relaxation, "the law of the intestine."

The purpose of this diphasic wave is almost self-evident: the wave of contraction at and behind the advancing mass of intestinal contents gives the propelling force which drives the mass slowly forward, while the relaxation wave in front makes the passage easy by widening the lumen of the portion of gut into which the mass is being pressed, and so diminishes the resistance to its progress.

That true peristalsis, when under the influence of the nerve cells of Auerbach's plexus, passes only in one direction is beautifully demonstrated by a procedure due to Mall, in which a loop of gut is resected, and then, in one experiment is replaced in normal position, and in another experiment is replaced in a reversed direction so that what was normally the upper end is afterward the lower end. In the first case, peristalsis remains normal and no obstruction occurs, but in the latter the waves pass from lower to upper end in the resected portion so that obstruction occurs when the food is other than of a thin fluid consistence.

It may here be pointed out that this local reflex forms an important distinction between the peristalsis of the œsophagus and that of the intestine. The difference is illustrated by the effects of completely severing transversely the muscular coats of the two tubes and then exciting a wave of contraction above the section of injury; when, in the case of the œsophagus, the peristaltic wave passes the point of severance as if no disunion existed and without any period of delay whatever, while in the case of the intestine the wave is completely stopped and does not appear at all in the lower segment of the gut.

The pendular or rhythmic movements are best seen when the peritoneal cavity is opened under a bath of warm saline. They recur fairly regularly with a rhythm of ten to thirteen per minute, and are caused by contraction waves which travel many times more rapidly than the true peristaltic waves, viz., at the rate of 2 to 5 cm. *per second*, as compared with 2 cm. *per minute* (*vide supra*).

It is only comparatively recently that physiologists have reached the conclusion that the pendular movements first noticed by Ludwig and the rapid rhythmical contractions of the wall arise from a common cause, viz., the simultaneous contraction of both circular and longitudinal muscular coats. When inspected by the eye alone the pendular movements which cause oscillating translatory movements of the loops of gut as a whole, backward and forward, are not apparently connected with any change in the cross section of the intestine. When, however, a distended rubber ball connected with a recording tambour is placed in the intestine it is at once obvious that a synchronous rhythmical change in volume of the intestine accompanies the swaying movements, further that any factors which influence the amplitude of one form of movement similarly and correspondingly alter the other, and that both become completely inhibited together by stimulation of the splanchnic nerves. There is hence little doubt that the older view, which attributed these pendular movements to the contractions of the longitudinal fibres only, is erroneous, and that they are merely an accompaniment of the rapid rhythmic contractions.

The purpose of these rapid rhythmic movements is not, as in the case of the true peristaltic waves, to force the food along the intestine. Digestion would be almost completely prevented by them, if they forced the food along at the rapid rate at which they travel, for the food would then traverse the entire intestine in a few minutes. Further, examination by means of the Roentgen rays of food to which subnitrate of bismuth has been added, as it is undergoing digestion in the small intestine, demonstrates that several hundreds of such waves may pass over a long mass of food without causing it to move downward in the slightest degree. Onward progress takes place at intervals only, when the quite distinct wave of true peristalsis sets the contents in translatory movement.

Although the intestinal movements are co-ordinated by the local nervous mechanism, control is exercised upon them by the central nervous system, chiefly through the vagi and splanchnic nerves. Various opinions have been expressed as to the action of the vagus, but the most careful experimentation upon the subject is that of Bayliss and Starling, who found that the effect obtained increased with successive stimulation, and that the most typical result obtained was an inhibition with a latent period of less than one second, followed by an augmentation in amplitude of the rhythmic contractions, which augmentation develops after an interval of from ten to thirty seconds and lasts for some considerable time after the cessation of the stimulus. Stimulation of the splanchnic nerve invariably causes diminution of the rhythmic movements and, when the stimulus is sufficiently strong, complete stoppage of the movement, which lasts for a few seconds after the stimulus is removed.

The Roentgen rays were first utilized for the study of the effect of the rhythmic movements on the intestinal contents by Grützner, who administered insoluble pellets containing nitrate of bismuth with the food, and found that these were chiefly rolled about from side to side of the intestinal tube in an oscillatory fashion by the rapid waves, while their progress along the intestine was very slow and inconstant, being sometimes for a short interval retrograde.

This method of studying the effects of the rhythmical contractions upon the intestinal contents has recently been improved by Cannon, who, instead of administering insoluble pellets containing the bismuth salt, has mixed the latter, to the extent of ten to thirty per cent. in fine powder, with the food. Cats were the animals experimented upon, and the food used was powdered salmon mixed as described above with subnitrate of bismuth (see also *Stomach, Shape, Position and Movements of*).

Cannon's experiments demonstrate that the most important result of the rapid rhythmic movements is the segmentation and resegmentation of the food many times repeated, with the result that the contents are intimately mixed with the digestive juices and that new surfaces are constantly exposed to the villous wall, by which means the process of absorption is enormously facilitated and hastened. A large mass is almost simultaneously divided into many minute segments, each segment is then again divided and the parts of adjacent segments are combined to form a new segment. This process is continuously repeated many hundred times, so that the contents are in this way most intimately mixed up with the digestive secretions.

Movements of the Large Intestine.—The movements of the large intestine have also been investigated by Cannon, using the method which has been indicated above in connection with the movements of the small intestine. He finds that the usual movement of the transverse and

ascending colon and cæcum is an *antiperistalsis.* The movements occur in intermittent periods, which come on at intervals of about fifteen minutes. Each period of activity lasts for about five minutes, and is followed by a quiescent interval of about ten minutes. The waves recur during an active period at the rate of eleven waves in two minutes. During activity the ileo-cæcal valve is closed and the contents are hence churned up, intimately mixed, and exposed to absorption, without in any way interfering with the processes going on in the small intestine. When new portions of material enter the large intestine, a strong general contraction sets in along the cæcum and ascending colon so forcing some of the material already present onward. As soon as this has been effected the antiperistaltic movements described above commence. With the accumulation of material in the transverse colon, deep tonic constrictions appear one after another and carry the material into the descending colon, thus leaving the transverse and ascending portions free for the play of the antiperistaltic waves.

Cannon found the ileo-cæcal valve perfectly competent for material passing in the ordinary course of digestion from ileum to colon, regurgitation into the small intestine never being observed; but in the case of a nutrient enema exceeding a certain bulk, regurgitation did occur, under the pressure of the antiperistaltic waves, into the empty ileum. Such a regurgitated nutrient enema underwent segmentation in the small intestine exactly as in normal digestion.

Cannon further observed that strong emotion, caused by fear, distress, or rage, totally inhibited all the intestinal movements. The movements continue in a normal fashion while the animals are asleep.

Benjamin Moore.

The literature relating to intestinal movement is an extensive one, but a key to most of the researches on the subject will be found in the following papers in which earlier work on the subject is also reviewed:

Bunch: Journ. of Physiol., 1897, vol. xxii., p. 357; *ibid.*, 1899, vol. xxiv., p. 72.

Grützner: Arch. f. d. ges. Physiol., 1898, Bd. lxxi., S. 492.

Bayliss and Starling: Journ. of Physiol., 1899, vol. xxiv., p. 99; *ibid.*, 1901, vol. xxvi., pp. 107–125.

Starling: Schäfer's Textbook of Physiology, 1900, vol. ii., pp. 326–335.

Cannon: Amer. Journ. of Physiol., 1902, vol. vi., p. 251.

INTESTINAL OBSTRUCTION. (SURGICAL.)—In describing the treatment of this affection, acute and chronic obstruction will first be dealt with generally, and after describing in detail the various remedies and methods employed, the special treatment of the individual forms of obstruction will be considered.

ACUTE OBSTRUCTION.—The treatment of acute obstruction is a subject surrounded with difficulties, and one about which there was formerly a great variety of opinion. The men of the older generation relied entirely on the "rest, opium, and starvation" treatment, and held that operative measures are seldom, if ever, necessary; the modern surgeons, on the other hand, think that the treatment by "rest, opium, and starvation" is almost useless, and the employment of such treatment is a waste of valuable time if the diagnosis of acute obstruction is correct. The only sensible procedure is to open the abdomen and if possible find out the cause and, if possible, remove it.

The practitioner without much experience, looking into his text-book for guidance, might imagine, from the very exact description given of the symptoms peculiar to each form of intestinal obstruction, that the differential diagnosis is a simple matter, and that should he meet with a case, he would only have to employ a certain method of treatment for a certain form of obstruction, and so relieve his patient, if relief were possible. In actual practice, however, the diagnosis of the special form of obstruction we have before us is by no means easy, and in most cases the exact nature of the affection cannot be determined except by laparotomy, or on the post-mortem table. The sermons preached daily by the morbid anatomists are valuable checks to the sin of diagnostic dogmatism in abdominal affections.

There are, however, certain general principles to be followed in cases in which acute obstruction is evident.

In the early period of these cases purgatives should be strictly avoided; enemata may be administered, but purgatives never. Food should not be given to the patient by the mouth, as it is always rejected, but the strength should be maintained by nutritious enemata.

If, after washing out the lower bowel several times, the fluid injected returns unchanged, and at the same time the vomiting continues incessantly, no relief can be hoped for by any other means than laparotomy. Delay in these cases is most dangerous; we should not wait for the vomiting to be fæcal (that is evidence of obstruction of some duration), but should open the abdomen at once, for the earlier the operation is performed the greater are the chances of success. In the fatal cases following operation this result is not, as a rule, caused by the laparotomy, but by its too late performance and the advanced condition of the grave changes in the bowel which result from the long-continued obstruction. This is especially apt to be so in those subacute cases due to intussusception, local inflammation, and hernia, in which, the symptoms not being very urgent, operation is delayed till too late (Wheelhouse). Wheelhouse [1] says the previous history of the patient is important. "If he has had peritonitis, perityphlitis, enteritis, or other inflammations where lymph may be poured out and bands afterward form, the indications for operation are more urgent."

In those cases which have all the symptoms of a strangulated hernia, and yet no hernia can be made out externally, it is reasonable to suppose that the case is one of internal strangulation, which can be relieved only by operation, as reduction by taxis is out of the question.

In subacute cases which have lasted five or six days, many patients, if operated on, die of exhaustion, and, according to Mr. Treves,[2] in cases of intussusception, after death a process of spontaneous cure, nearly complete, has been found, and apparently was arrested only by exhaustion owing to the patient's inability to take food.

In CHRONIC OBSTRUCTION, where there is reason to believe that a stricture exists in the intestines, due to internal or external causes, it is very important that proper food should be taken, so that nothing that is not perfectly fluid or in a pultaceous condition should enter the bowel. The swallowing of all indigestible substances, such as orange pips, plum or cherry stones, raisins, etc., should be strictly avoided. Should constipation be present, mild laxatives may be cautiously administered, or simple enemata, but *purgatives should on no account be given.* If the stricture be within reach, as, for instance, in the rectum, it may be dilated with bougies or incised. Excision of a cancerous stricture of the lower end of the rectum is an operation which has afforded very good results, and, if performed early, the life of the patient may be prolonged for years and his comfort not seriously interfered with. When almost complete obstruction occurs from narrowing of the lumen of the bowel by the increased growth of the stricture, then the question arises as to the advisability of establishing an artificial anus. If the growth can be felt through the rectum, inguinal colotomy should be performed, if it is deemed inadvisable to excise the growth. Cancerous strictures nearly always occur in the large bowel, and, if the stricture cannot be felt through the rectum and the age and appearance of the patient indicate malignant disease, an exploratory operation should be undertaken and an endeavor made to excise the growth, bringing the cut ends of the bowel together with sutures or Murphy's button.

If the stricture be in the small bowel the abdomen should be opened and an artificial anus established, or the affected portion of bowel should be resected and the divided ends sutured or united by Murphy's button.

In cases of chronic obstruction which have lasted for months and the cause cannot be exactly determined, an exploratory incision is the proper procedure, for by the establishment of an artificial anus life may be, in many cases, much prolonged. Often the growth may be excised and the cut ends of the bowel brought together; and

for the success of this procedure, the earlier the operation is undertaken the better, before the system has become debilitated, as the better the condition of the patient at the time of operation so much the greater is the chance of success. Patients, as a rule, refuse operation till the discomfort of the obstruction is so great and their condition so deteriorated that operation is performed only as a *dernier ressort*.

METHODS OF TREATMENT IN DETAIL.—*Rest, Starvation, and Opium.*—This treatment is of very old date, and many yet believe it to be the only treatment that should be pursued in cases of acute intestinal obstruction. It consists, in short, of entire abstinence from food, from physical exploration of the parts, enemata, etc., and the administration of opium or morphine. All are agreed as to the propriety of adopting this treatment in the very early stages of acute cases, but, as already mentioned, surgeons of the present generation are in favor of further treatment by operation.

Opium.—Many cases of obstruction are recorded as being cured by the free administration of opium; it is certainly very probable that not a few cases of commencing invagination have ended favorably by its administration. But we must not trust to opium, even when combined with rest and starvation. Opium has its dark as well as its bright side, and if given early in cases of obstruction it obscures the symptoms and so lessens the chance of making a diagnosis; the patient's condition, no doubt, improves, vomiting and pain may be less, the pulse better, and the skin moist; but at the same time the bowel may be in a gangrenous condition, and the patient dies only the easier from having been dosed with opium. Again, the lessening of the severity of the symptoms may so lull the suspicions of the medical attendant that operation is delayed and the patient deprived of his only chance of life. I repeat that opium is a valuable drug in the treatment of obstruction if used with discretion, and with a full knowledge of its effects; it is rarely curative, but always relieves pain and lessens the peristaltic action of the bowels.

Belladonna.—Dr. Brinton first introduced the use of this drug in the treatment of intestinal obstruction, because of its power to produce relaxation of the unstriped muscular fibres of the bowel. Many speak very highly of it used alone or in combination with opium, as it lessens the sickness and depression caused by opium given alone. It may be administered by the mouth, or atropine may be injected hypodermatically. It has been used externally on the abdomen in form of ointment or plaster. Belladonna is sometimes useful in cases of fæcal accumulation, or in cases of paralysis of the bowel due to sepsis, but in cases of true obstruction it can be of but little service.

Enemata.—In cases of chronic obstruction of the bowels enemata are of considerable benefit; they are especially useful in those cases in which vomiting occurs. In cases of obstruction due to fæcal accumulation enemata are particularly beneficial. Warm water is generally sufficient, by repeated injections, to clear out the large intestines, but in cases of impacted fæces enemata of sweet oil, with one drachm of spirits of turpentine to the pint, give extremely satisfactory results.

Enemata have frequently proved useful in effecting the reduction of an intussusception; to be of service they must be administered early and copiously. Some recommend that they should be administered with the patient in the inverted position.

In cases of acute obstruction the benefit of enemata is not so clear; many medical men in these cases object to them altogether, because they are liable to increase the peristaltic action of the bowels.

In certain cases enemata are inadmissible and often injurious. They cannot possibly be of benefit in cases of intussusception in which the invaginated bowel has reached low down, in stricture of the rectum, or in cases of volvulus of the sigmoid flexure; in this latter affection enemata only increase the amount of twisting, and so do infinite harm.

Some surgeons recommend that copious enemata should be given, in every case of intestinal obstruction, before any other method is tried. Dr. Illoway,[3] not content with the ordinary enema syringe or siphon apparatus, recommends the use of a force pump which can throw a continuous stream; if this fail, then he advocates laparotomy. In reading over the account of the discussion on intestinal obstruction at the Liverpool Medical Institution,[4] the writer was much struck with some remarks of Dr. Barr, and thought that they applied to those cases of intestinal obstruction successfully treated by enemata. Dr. Barr said: "If you look upon all cases where you have got severe pain in the abdomen, constipation, and vomiting, with perhaps more or less shock, as cases of intestinal obstruction, then, no matter what line of palliative treatment you adopt, you ought to have a very good percentage of recoveries; but if you belong to a more exclusive school, and in your anxiety for accurate diagnosis eliminate all cases of colic, constipation, enteralgia, etc., then you will find you have a terrible disease left, which tends more frequently toward a fatal issue than to recovery."

If we were as certain of the correct diagnosis of the disease treated as of the successful result of the treatment in many of the reported cases, much confusion and difference of opinion as to the value of certain remedies in the treatment of intestinal obstruction would be avoided.

Enemata have been used for diagnostic purposes. If during the injection the fluid can be heard gurgling in the cæcum, it is almost certain that the obstruction is in the small intestine; if it is stopped at some intermediate point, it is probable the obstruction is at that spot.[5]

Metallic Mercury.—This very old method of treatment is now never practised, though comparatively recently it has been advocated by Matignon, of Paris, and cases of intestinal obstruction successfully treated by this means are occasionally reported in the journals. The cases in which it is of use are those of old fæcal accumulation; for other forms of intestinal obstruction it should never be employed; it cannot possibly do good, and may do much harm.

Shot.—Dr. Maydieu,[6] of Paris, reports cases of ileus successfully treated by the administration of shot. He mixes seven ounces of shot with four ounces of olive oil, and gives two drachms of the mixture every half-hour. This treatment may do more harm than good, and is mentioned merely as a curiosity. It replaces the treatment by bullets of the physicians of the sixteenth century.

Washing Out the Stomach.—Kussmaul was the first to introduce washing out of the stomach for intestinal obstruction, and a number of successful cases are reported as the result of this mode of treatment. The good result is explained on the ground that evacuation of the distended bowel affords opportunity for the spontaneous reduction of a herniated or twisted loop of bowel. The temporary relief afforded is said to be very great, and the practice is so simple and harmless that it is worthy of a trial. Of course, the majority of cases of intestinal obstruction could not possibly be relieved by it.

Massage and electricity have been extensively practised in the treatment of intestinal obstruction and still have their advocates. It is now the opinion of most surgeons that in cases of acute obstruction, at any rate, they do more harm than good. The only cases of obstruction likely to benefit by them are those due to fæcal accumulations. E. O. Day[7] reports two cases of intussusception successfully treated by massage. He had seen ten cases of this affection, and the only recoveries were the two treated by manipulation and massage.

Puncture of Bowel with an Aspirator Needle or fine Trocar.—This method has its advocates, and cases are reported in which, after the bowel has been punctured and a large amount of gas and fluid fæces evacuated, the obstruction has been relieved. As a rule the procedure is not a dangerous one, but occasionally, owing to paralysis of the coats of the bowel, the punctures do not close, fæces escape, and a fatal peritonitis is the result. At best, puncture is a proceeding in which the element of

chance exists to a large extent; one can never tell whether the proper part is punctured, or whether the needle has not entered a portion of bowel bordering on gangrene. Mr. Treves [8] has met with several instances in which perforation of the bowel, which had been previously threatening, took place immediately after the relief of the distended coil by puncture.

In some cases the needle has punctured the bowel below the obstruction, without, of course, relieving the patient.

Emptying the bowel above the obstruction may in certain cases relieve a portion of the gut which is in some abnormal opening or held lightly under a band, and may relieve obstruction due to kinking. In cases of stenosis in which there is temporary obstruction it may give relief, and also in those cases of chronic obstruction which suddenly become acute (Treves).

Puncture of the bowel is a favorite method of procedure with veterinary surgeons for the relief of distended bowel in cattle. A very large trocar is used, and no evil results ever follow, owing to the immunity cattle have from peritonitis.

Dr. Larguier, of Paris, speaks highly of the continuous use of a trocar. He introduces a trocar 5 to 6 mm. in diameter, and leaves it in the intestines two or three days. Sometimes fæcal fistulæ are formed (Treves). As this operation must necessarily be done at haphazard and is not free from danger, it cannot be recommended.

Laparotomy.—Surgeons are daily becoming more and more certain of the necessity of this operation in the majority of cases of obstruction; there is still some difference of opinion as to the cases in which it is suitable, and also as to the proper methods of its performance, but a larger experience will soon enable us to lay down definite rules for the guidance of surgeons. C. L. Gibson,[9] of New York, has collected 646 cases (exclusive of hernia) of intestinal obstruction treated by laparotomy with a mortality of 47 per cent.

The incision should be made in the median line below the umbilicus, and should be long enough to allow the whole hand to enter the abdomen. Having opened the peritoneal cavity, after all hemorrhage has been arrested the hand should be introduced through the wound, and the right iliac fossa first examined. If the obstruction be not found in cæcum or ileum, collapsed coils of intestine should be searched for. These are generally found hanging in the pelvis. If found, they can be passed through the fingers till the constriction is reached. Mr. Treves [10] advises that a large, warm, carbolized sponge should be placed in the pelvic cavity, as by this means much manipulation is saved. The intestines should, if possible, be prevented from extruding by means of warm flat sponges or aseptic gauze pads wrung out of hot water. The extrusion of intestines, if much distended, as they are almost sure to be, gives rise to considerable trouble, and if they cannot be kept within the peritoneal cavity, it would be well to incise the most distended portion and allow the gas and contents to escape. The incision should afterward be closed by a Czerny-Lembert suture. If the obstruction cannot be made out by the introduction of the hand, it would be proper to allow the bowel to extrude and to make a systematic search. The extruded bowel should, of course, be protected by warm aseptic gauze towels. Mr. Greig Smith [11] says the most dilated portion of the bowel rises to the surface, and there is a great probability that the obstruction will be found near this point. The hernial orifices should be examined, also the foramen of Winslow, the sigmoid pouch, duodenojejunalis fossa, etc., the diaphragm must not be overlooked, openings in the mesentery searched for, the presence of a tumor or intussusception as a cause must be kept in mind; also Meckel's diverticulum or the possibility of a properitoneal or retroperitoneal hernia.

When the obstructed point is found, the intestine should be carefully examined; if of good color it should be returned, but if gangrenous it should be excised and the cut ends immediately sutured, or an artificial anus established. If the obstruction be due to constricting bands, these should be divided between the two catgut ligatures. Should an intussusception exist, it may be reduced by gentle traction if the case be a recent one; but if the parts be tightly glued together by effused lymph, so as to render reduction impossible, the affected portion of bowel should be resected and sutured, or an artificial anus should be established. Occasionally in these cases the obstruction is found to be due to cancerous or other stricture, or to a peritonitis; if the former condition exists and excision is impossible, an artificial anus should be established above the constriction; if the latter is the cause of the trouble, the peritoneal cavity should be washed out with a normal saline solution.

It is possible, nay probable, that the cause of the obstruction may not be found, for it is by no means easy thoroughly to search the abdominal cavity (even if the whole hand is introduced) when the bowels are greatly distended; in such a case it is the duty of the surgeon to establish an artificial anus in the most distended portion of bowel, and to await results.[12] In cases operated on late, the value of decinormal saline solution injected subcutaneously, or the intravenous introduction of the solution cannot be overestimated. Even rectal injections are of benefit, and filling up the abdomen after operation with hot saline solution and leaving it there is a most useful antidote to shock.

Polaillon [13] advises lateral laparotomy in preference to the median incision in cases of intestinal obstruction; with this incision, he holds that the distended intestines are less likely to extrude, and that the wound is more easily closed. The lateral incision should be made in the inguino-iliac region, parallel to the fibres of the external abdominal oblique muscle. Here the lips of the wound close easily, and the diaphragm is less liable to force the distended bowel through the wound. This incision is all very well if the point of obstruction is diagnosed and is on one side or the other, but in the majority of cases we are quite in the dark as to the site of the obstruction, and for a systematic exploration of the abdominal cavity no incision is so convenient and useful as the median.

Enterectomy is called for in certain cases of intestinal obstruction; for instance, those due to simple and malignant strictures of the small intestine, neoplasms, irreducible intussusception, and also in those cases in which on opening the abdomen the bowel is found to be in a gangrenous condition. It has been most frequently performed for the latter condition. After the affected portion of bowel has been resected, the question then arises as to the propriety of immediately uniting the divided ends of the bowel by suture, or of establishing an artificial anus by fixing them to the abdominal wound. The latter method, in cases of intestinal obstruction in which the condition of the patient is by no means good, is probably the better one. The immediate suture of the bowel prolongs an already severe operation, and so lessens the patient's chance of recovery.

If desired, when the patient recovers, and regains his strength, the artificial anus may be closed by a second operation. For the manner of performing resection the reader is referred to the article on *Intestinal Surgery.*

Enterotomy.—This operation for the relief of obstruction was first performed by Nélaton, and consists in opening the small bowel in the right loin, by an incision, a little above the crest of the ilium, parallel with Poupart's ligament. It has been performed many times with success, and is more suitable to the more chronic forms of obstruction when, owing to the disease being high up in the large intestine, left inguinal colotomy is unsuitable. The portion of bowel opened is generally the lower end of the ileum. It is also performed in those cases of intestinal obstruction in which, after the abdomen is opened, the affected portion of bowel cannot be resected. In cases of recovery the patients complain bitterly of the situation of the fæcal fistula, as no apparatus seems to be able to keep in the discharges.

For the treatment of obstruction due to herniæ, the reader is referred to that subject, also the treatment of diaphragmatic hernia (of which Gibson has collected

thirty-four cases), and gangrenous hernia must be looked for under the head of *Hernia*.

TREATMENT OF SPECIAL FORMS OF OBSTRUCTION.—*Treatment of Internal Strangulation.*—If the obstruction be complete and the symptoms very acute, the immediate performance of laparotomy is called for. Whatever be the cause of the strangulation, laparotomy is our only hope of effecting a cure. Occasionally, but very occasionally, the patient may recover owing to the bursting of a constricting band or the spontaneous reduction of a herniated loop of bowel, but we should not wait for the chance of a cure being effected by nature. The immediate danger is too great, and the hope of a natural cure too slight, to justify us in postponing opening the abdomen and relieving the obstruction. There is no reason why these cases should be treated in any way differently from those of strangulated hernia when reduction by taxis has failed. Some go even further than this, and recommend that where this form of obstruction is suspected the patient should not be allowed to die without an exploratory laparotomy.[14] There is far more danger in operative interference being delayed until the period when it may be of no avail, than that a hasty and unnecessary operation should be done (Pilcher[15]). Opium may be given to relieve pain and lessen peristaltic action, but it is useless to trust to it as a curative measure. Enemata may prolong life, but cannot cure the disease. Its apparent improvement, due to the administration of sedatives, etc., should not deceive the surgeon or encourage him to postpone operative measures.

Volvulus.—This occurs most frequently in the sigmoid flexure. Rest, starvation, and opium may delay the fatal issue, but will never relieve the volvulus. Enemata are injurious, as they tend to increase the twist by distending the bowel. Laparotomy is the only method of treatment that affords any reasonable hope of success, and, to be of benefit, it should be performed early. When the operation is performed, and the volvulus found, its reduction is by no means a simple matter, even after the distended bowel has been relieved by puncture or incision. If reduction is impossible, an artificial anus should be established or the bowel resected. Volvulus was seen in 121 cases of the 646 collected by Gibson, and of these 66 per cent. ended fatally after operation. In 79 cases the bowel was untwisted and only 29 per cent. were fatal; 81 per cent. ended fatally after resection or artificial anus.

Bands.—Of the 646 cases of intestinal obstruction operated on, and tabulated by Gibson, 186 were due to bands; of these 76 were fatal (41 per cent.); most of these bands occurred in connection with the small intestines. In 126 the bands were cut or removed, and the mortality was 26 per cent. Owing to gangrene, resection had to be done in 17 cases, with a mortality of 52 per cent. This gave a better result than artificial anus, in which in 18 cases the mortality was 94 per cent. It is well to remember that there may be more than one band; failure to search for a second band has been the cause of more than one death.

Intussusception (Acute).—There is no doubt that occasionally intussusception, if recognized early, before adhesions have formed, may be treated successfully without operation. It is unnecessary to state that purgatives are harmful, and that expectant treatment, when every moment increases the severity of the affection, is of no avail. Mr. Jonathan Hutchinson has said[16]: "I have not found any case recorded in which spontaneous return of a well-recognized intussusception occurred, and those in which art succeeded are comparatively rare." If we are certain that the case is one of acute intussusception then immediate operation is called for. Insufflation of air or the injection of water have long been advocated as early treatments, and many yet believe in them; for some time, however, the modern surgeon has considered these measures mere loss of time, and prefers immediate laparotomy. The methods of insufflation and of administering enemata are given below.

Mr. Clement Lucas[17] advises the following method of inflation: "An ordinary bellows is connected with a gum-elastic enema tube by means of a piece of rubber tubing which is firmly wired at the end; around the end of the enema tube lint should be wrapped so as to make a conical air-tight base; the tube is inserted about three inches into the rectum, and the anus closed by a conical plug of lint. Further to guard against the escape of air, an assistant should press the buttocks of the patient close together; an anæsthetic should be administered." Mr. Lucas advises that inflation should be performed with the patient in the inverted position.

There are different methods of administering enemata: the ordinary enema syringe will do very well, but the fountain or siphon syringe is much better. The return of water is prevented by an assistant, who presses the buttocks of the patient firmly together. The water should be warm, and should be injected slowly and continuously. The difficulty of retaining the injected fluid may be obviated by the employment of Lund's elastic ring and handle.[18] This instrument was devised by Mr. Lund to prevent the return of air in insufflation, and so is suitable to cases in which either air or water is injected.

Should the surgeon be fortunate enough to effect reduction by these means, the after-treatment is simple: milk diet, with small doses of opium to relieve pain and give rest to the parts.

Laparotomy by median section is the preferable operation. If, on opening the abdomen, reduction prove impossible owing to the firmness of the adhesions, the affected portion of bowel should be resected and the divided ends immediately sutured and returned into the abdomen, or stitched to the abdominal wound, and an artificial anus established. Dr. Charles L. Gibson,[19] of New York, has collected 187 cases in which an operation was done for intussusception, with a mortality of 51 per cent.; 81 cases were in children under one year, and of these 38 died and 43 recovered. The invagination was reduced in 126 cases, with 46 deaths and 80 recoveries. Resection was performed in 32 cases, of which 26 were fatal. Artificial anus was made in 5 cases, of which all were fatal. Resection and artificial anus in 19 cases, with 14 deaths. Twenty-three cases were gangrenous and only one of these patients recovered. The results of early operations in these cases of intussusception are fairly satisfactory.

Widerhofer and Herz,[20] of Vienna, report each a series of 10 cases of laparotomy for invagination, with 3 recoveries in each series, or a mortality of 70 per cent.

Weinlechner advocates median laparotomy within twenty-four hours in children and forty-eight in adults.

Other methods of treatment are advocated for acute intussusception. Kussmaul recommends the free washing out of the stomach. Busch[21] has practised massage three times without success. When low down, reduction by bougies has been well spoken of by some, but this treatment is dangerous and cannot be recommended.

Weinlechner,[21] when the invagination is low down in the sigmoid flexure or in the rectum, has five times ligatured the invaginated portion by introducing a rubber tube and passing a ligature over it. Others,[22] when the invagination was low down, have cut off the invaginated portion, and then returned the bowel.

L. W. Hotchkiss (*Annals of Surgery*, November, 1901) has drawn attention to the fact that acute obstruction may occur after the operation for appendicitis; it must not be forgotten that acute obstruction may be one of the sequelæ and persistent vomiting the invariable symptom. This vomiting of course may be caused by sepsis, and if in any doubt it would be well to open the abdomen in the middle line and examine. These cases are more frequent than is generally supposed, and the only hope is early operation. Obstruction may come on a few days or weeks, or even a year, after the operation. I have seen and operated on cases at all these periods, and success has followed early operation.

Intussusception (Chronic).—Chronic intussusception is attended by a great mortality. Medicinal treatment is of little avail; opium and laxatives give temporary relief, and reduction has in rare cases been effected by inflation and enemata. The only means by which relief can be

hoped for when the foregoing measures have failed is abdominal section. If, when the abdomen is opened, the reduction cannot be accomplished, the whole mass ought to be excised and an artificial anus established.

In some cases in which the intussusception is low down and chronic, it may be temporarily relieved by the performance of a right inguinal colotomy.

Foreign Bodies.—The cases of obstruction caused by foreign bodies are not common. Gall stones are most frequently the foreign bodies found. Free doses of opium should be given, followed by aperients, and, when complete obstruction exists, laparotomy should be performed, the intestine incised, and the wound closed with a Czerny-Lembert suture and the bowel returned. Gibson has collected 40 cases of gall stones which were operated upon because of the obstruction produced; of these 21 were fatal (57 per cent.). Lange[23] reports a case of obstruction caused by impacted gall stones and general peritonitis. Laparotomy was performed, but the patient died in eight hours. Dr. H. F. Beam[24] relates a case of intestinal obstruction caused by a calculus in the ileum the size of a walnut; it could be felt through the abdominal walls. An incision was made over the spot and the calculus removed. The patient made a rapid recovery. In incising the intestine to remove a gall stone it is better not to incise directly over the stone, for at this point the intestine may be injured by pressure of the stone.

P. J. Wising,[25] in recognized cases of ileus from gall stone, recommends first the employment of purgatives; if these fail, then copious enemata of water. Simple enemata, he holds, are perfectly harmless, but those of an irritating character should be avoided. Opiates should be given, and the strength of the patient sustained by nutrient enemata. He does not advise early laparotomy, but says that, when everything else fails, it should be undertaken.

Fæcal Accumulation.—Obstruction due to fæcal accumulation is of occasional occurrence. The point of obstruction is generally in the rectum, which is filled with a hard, immovable mass, above which the bowel is much distended with semi-fluid fæces. The best means of relief are afforded by copious enemata of warm water administered in the knee-and-elbow position. Continuous irrigation by the siphon syringe is very efficacious, and, if employed for half an hour at a time, the hardest mass softens and gradually becomes disintegrated. The stream of water should be directed against the obstructing mass by means of a rectal tube. Before enemata are commenced it is often advisable to inject a few ounces of olive oil. Some physicians recommend copious injections of sweet oil with spirits of turpentine in the proportion of one drachm to the pint of oil. Metallic mercury was a favorite remedy with the old physicians, and has been strongly advocated by Matignon, of Paris. Occasionally, when low down, the fæcal mass may be removed by scoop or spoon.

Colotomy has been performed in cases of obstruction due to fæcal accumulation. In most of these cases, however, there has been a mistake in diagnosis. It can be only rarely required in fæcal obstruction, and should not be resorted to till all other means of relief have failed.

Stricture.—The treatment of obstruction due to stricture is considered under Chronic Obstruction.

Francis J. Shepherd.

[1] British Medical Journal, April 18th, 1885.
[2] Intestinal Obstruction, p. 420.
[3] American Journal of the Medical Sciences, January, 1886.
[4] Lancet, December 13th, 1884, p. 1065.
[5] J. K. Fowler: London Lancet, June 30th, 1883.
[6] Bull. de Thérapie, May 15th, 1870.
[7] London Lancet, vol. ii., 1885, p. 570.
[8] Intestinal Obstruction, p. 449.
[9] Annals of Surgery, vol. xxii., 1900.
[10] British Med. Jour., August 24th, 1885.
[11] *Ibid.*
[12] See case of Mr. Lawson, London Lancet, vol. i., 1879, p. 87.
[13] Gaz. Méd. de Paris, April 25th, 1886.
[14] John Syer Bristowe, in Reynolds' System of Medicine, vol. iii., p. 83.
[15] New York Medical Journal, February 20th, 1886.
[16] Medico-Chirurgical Transactions, vol. lvii.
[17] London Lancet, January 16th, 1886.
[18] *Ibid.*, 1869, vol. ii., p. 609.
[19] *Loc. cit.*
[20] Quoted in La Semaine Médicale, April 7th, 1886.
[21] La Semaine Médicale, April 7th, 1886.
[22] Fuller in New York Medical Record, October 14th, 1882.
[23] Medical News, January 16th, 1886.
[24] New York Medical Record, October 17th, 1885.
[25] Nord. Med. Ark., Bd. xvii., No. 18 (quoted in Centralblatt f. Chir., No. 20, 1886).

INTESTINAL SURGERY.—This field of surgical work differs slightly from others in certain essentials affecting natural repair of serous surfaces—and in the understanding of a few mechanical aids which are necessary to successful healing of intraperitoneal wounds.

The peritoneal cavity is so susceptible to contamination and so quick to yield fatal results if soiled, that it was considered a forbidden field of invasion prior to the present generation of surgeons. Through accumulated and vast experience, however, it has now become possible to deal with it with perfect safety if established principles are recognized.

First in importance is recognition of the fact that no solution should be used in the peritoneal cavity but boiled water, to which a little salt has been added (ʒ iss. to O ij.—"decinormal salt solution"). This is entirely non-irritating to a healthy peritoneum and, for an infected one, is mechanically cleansing as well as destructive to the life of colon bacilli. Considerable quantities of it may, under certain circumstances, be left in the cavity with advantage, and in any event with safety.

The second underlying principle—which applies here as elsewhere—is, that nothing but aseptic gauze pads are to be used for sponging, and that aseptic ligatures, instruments, and hands (preferably covered by rubber gloves, boiled and dry-sterilized and free from punctures) can be relied on to insure safe work.

The third principle covers the understanding of repair by lymph exudate, the process being peculiar to this field, and of the mechanical aids which the surgeon may employ to bring it about. Under the latter are included the use of suture material and various ingenious mechanisms.

The student will understand that under favorable circumstances a firm lymph or gluey exudate, which is a natural means for repair, is promptly thrown out and spread around and upon any wound of the peritoneum, either visceral or parietal. It often begins to appear, firm and available to hold surfaces together, within two hours. The usual time, however, when it may be expected to afford efficient support, is after at least six hours have elapsed. In some cases a still longer period—one or even two days—may be required. Such a protracted delay depends on the poor disease-resisting power of the patient (feeble leucocytosis?), or, in certain cases, on the solvent action of bacteria in excess.

The presence of mechanical substances, or of chemical irritants, provokes a quicker formation of an exudate. Thus, the suture thread is, if it is aseptic, speedily buried in firm lymph—the first step in nature's effort to incarcerate it as a foreign body.

If, however, an impure suture material is used, one will see the parts speedily fall asunder owing to the solvent action of bacterial secretions.

The best suture material, it is universally conceded, is fine silk, sterilized by boiling, and black by preference, so that each stitch may more easily catch the eye of the operator.

The best needle is the ordinary round one, though with care an operator may use any variety. For much of the careful work necessary, it is better to have also a sharp-pointed needle, curved one-third of a circle, which, while having cutting edges, has a flat surface on the convexity (like an eye needle), and is not more likely than a round one to wound small veins and produce subserous hæmatomata. The spear-pointed, or Hagedorn, needle often causes troublesome bleeding.

Thus, with simple expedients and a recognition of the few simple principles enumerated, one may accomplish all that skill can do in effecting the repair of peritoneal wounds.

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A knowledge of certain stitches is essential to the technique of intestinal surgery. There are four varieties which deserve to be remembered, as they are competent to fulfil all the requirements of perfect work. These four methods, which are to be carried out on the peritoneal surface, are known as (1) the Lembert interrupted, (2) the Halsted interrupted, (3) the Lembert continuous, (4) the Cushing continuous.

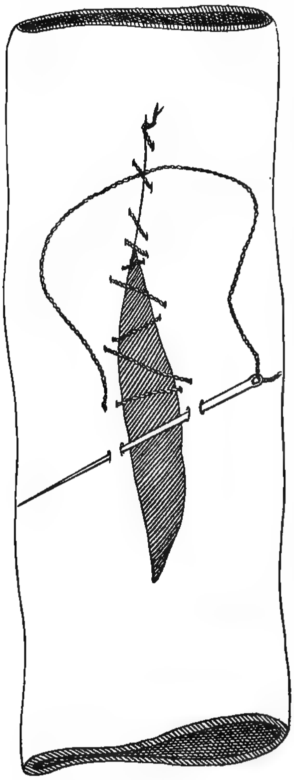

FIG. 2916.—Continuous Suture. (Lembert.)

When the edges of mucous membrane are to be united, a through-and-through stitch is now conceded to be the best. It was long regarded as essential that this stitch should penetrate only the mucous and submucous coats so as not to contaminate the peritoneal. Hence we hear of the Czerny-Lembert combined suture. But it was demonstrated many years ago by Gross and others that the stitch which penetrates all through each cut edge of united bowel secures them with inevitable firmness because it holds the fibrous layers of both, and no peritoneal contamination results because the bacteria follow the thread from one mucous surface through and out of the other, hence draining the puncture both ways.

It would be idle to say that many operators do not use other varieties of stitching—such as are depicted in all older works on surgery—but it is gratifying to find that those of largest experience are now agreed in using with confidence those just described. What one must have is absolute reliability coupled with simplicity.

The demonstration by Halsted that there is a tough subserous fibrous layer which resists the point of the needle more than any other layer in the intestinal wall, and which can be picked up and pierced reliably by the threaded needle, is a discovery of decided practical value in the treatment of intestinal wounds.

It is certainly true that if the needle unites only the peritoneal coats the stitch will inevitably tear away and leakage occur. If one stitch gives, the entire work is vitiated. A little experience soon enables the operator to penetrate and raise the right thickness of intestinal wall on the needle, though he must ever be alert to the fact that the bowel wall is extremely thin in some places and thick in others. Nevertheless, I believe it would be less perilous to the patient if the puncture went into the mucous coat than if only a feeble hold on the peritoneal layer allowed separation of the edges, because a very slow and insignificant contamination working along the thread toward the cavity of the peritoneum would probably be taken care of by a quick exudation of reparative lymph, whereas an escape of gas and fluid through the gap of a loosened suture might be confidently expected to excite a peritonitis.

There are few surgeons probably who would be satisfied to unite most wounds of the bowel with a single row of sutures. Hence, whether a through-and-through stitch of the bowel edge is employed, or one which penetrates only through the peritoneal coat, the operator usually reinforces it by a second row of stitches placed as close as possible to the first, thus not inverting so much as to narrow the lumen of the bowel. This second row of stitches are of either the interrupted or the continuous variety, and of either the Lembert, or the Halsted, or the Cushing type. My own preference is for the Halsted type, because I believe it to be more firm and enduring and because it requires half as many knots as the Lembert for a given line of repair.

The author is very strongly impressed, after much experience, with the value of the circular purse-string suture applied to the peritoneal surface and inverting such part as it is desired to close. A small punctured wound, for example, or, better still, the cut-off end of intestine—if it be desired to close it absolutely, as when lateral anastomosis is intended—can be best and quickest closed by a running stitch about the opening, applied to the peritoneal coat and tightened as the edge is inverted. The writer first used such a purse-string suture in 1884 in experiments upon animals, and he has since uniformly resorted to it in securing tubes in the alimentary canal for drainage or irrigation, or in closing small defects.

Before speaking of the various conditions under which intestinal surgery is demanded, we may well consider the various devices, more intricate than stitching, which are available and which have stood the test of active surgery during fifteen years past.

Thus, Jobert and Senn fastened a flat ring inside the end of the upper segment of the bowel by a few stitches inserted at its edge, and then, pushing this into the lower, inverted the latter so that two serous surfaces came together. When these were secured by a row of stitches uniting the two and keeping their surfaces in contact (throughout a width of one inch), the upper part discharged into the lower without leakage while union was taking place. Eventually the artificial ring was shed and discharged into the bowel.

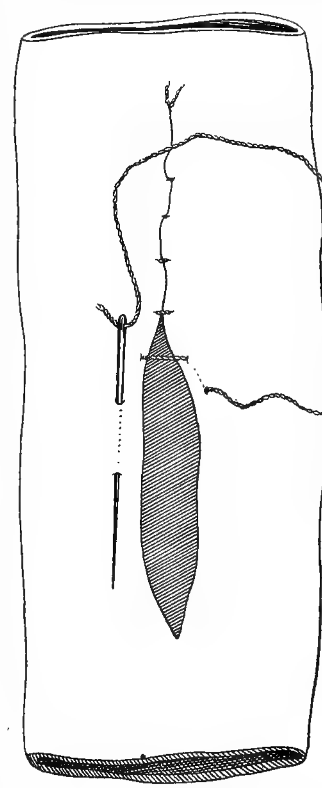

FIG. 2917.—Continuous Suture. (Cushing.)

This is a practical means of repair but lacks the neatness of other methods, owing to the necessary dragging in of some of the mesentery of the inverted bowel, thus affording chance of leakage unless most carefully guarded against. Moreover, it is contended that an intussusception thus initiated has a risk of progressing.

In the lateral implantation of small intestine into colon the procedure forms a satisfactory mode of repair.

Somewhat after the same idea is the much admired method of Maunsell, by which the two ends of bowel of the same calibre are united. In this method four silk

stitches passed through and through both edges at four equidistant points are drawn into the bowel and out of a long slit, cut lengthwise, a finger's length below the end. By the aid of these stitches both cut edges are pulled out through the same cut and quickly sutured by continuous (or interrupted) through-and-through stitching. This allows most perfect apposition. These sutured ends are then dropped back through the cut into the lumen of the bowel, and the continuity of the tube is seen to be established. A few nicely applied sutures are now used to close the longitudinal opening, and, after careful cleansing with salt solution, the repair is complete.

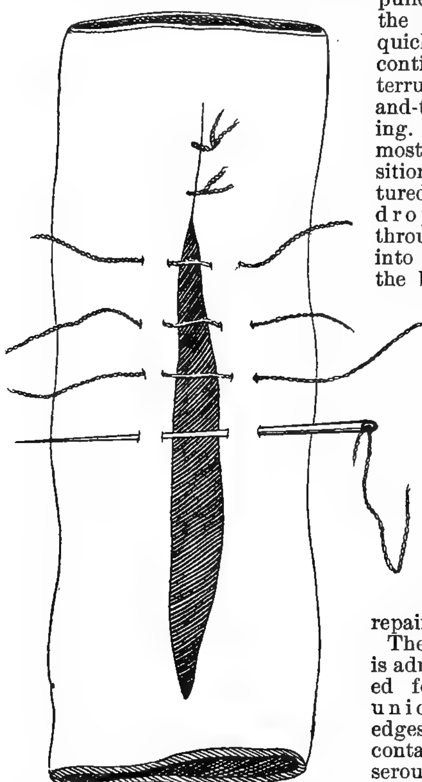

FIG. 2918.—Interrupted Suture. (Lembert.)

The Connell stitch is admirably adapted for end-to-end union. The cut edges are placed in contact by their serous surfaces. A straight needle carries a silk thread through both at one thrust, and back again. The knot is tied on the inside of the bowel and the stitch repeated round the entire circumference.

Discussion has not settled the question of preference as between the "end-to-end" and the "lateral" methods of uniting divided intestine. And it seems probable that occasions will always exist when one method appears to be preferable to the other.

Long experience has demonstrated that most sutured openings established in the bowel tend to contract in proportion to the surface area held in the grasp of the suture material. In all forms of lateral anastomosis, whether of stomach, bowel, or gall bladder, the law of cicatricial stenosis prevails strongly. No matter whether the union has been effected by sutures or by metal buttons, contraction is always sure to take place, and in the course of a year or a year and a half the aperture will, in many cases, have been reduced to half its calibre. This does not happen apparently in end-to-end union, either when sutures or when buttons are used. It has been observed to take place, however, when one end is implanted into the side of another portion. Therefore, when lateral anastomosis is done, a reasonable allowance must be made for such shrinkage. Inasmuch, therefore, as a one-inch, or at most a one-and-a-half-inch opening between bowels is ample for perfect function, it is necessary that the operator should cut a slit from two to three inches in length. Fortunately, it is so easy to suture the smooth side of one piece to another that the extra length makes little difference in time consumed, if continuous suturing is applied.

As an instance of the actual conditions under which the operation of lateral anastomosis is performed let us suppose that a portion of bowel has been cut away for cancer. The successive steps for remedying the defect thus created would be, first, to close the open end of each segment by a purse-string stitch, which is to pass only through the serous coat and is to be tightened in such a manner as to produce inversion of the edge of mucous membrane. A second purse-string stitch of black silk is always desirable but not entirely essential. This inverts the first knot still further and produces a nipple-like eminence inside the bowel. The two closed ends are then to be cleansed and laid alongside each other, preferably pointing in opposite ways. It is now intended to open a long slit in each, on the side opposite its attached mesentery, but the operator should first apply two continuous lines of sutures, parallel and close to the proposed cut on the side farthest from him. Having first passed iodoform tapes through the mesentery above and below the operated parts, and having tightened them just enough to hold the liquid contents of the bowel, he now cuts the intestinal opening near the sutured line and stitches both edges through and through on one side. This has the double advantage of securing firmer fixation and arresting any bleeding. The other edge needs no through-and-through stitching, but the two parallel rows of stitches, which are now at the back of the cut, are continued round the ends and on to the opposite side. Thus a union is secured which cannot leak under even hydrostatic pressure, and which is indeed subject to little strain from within, owing to the very free transit of liquid contents through the large opening thus established.

The parts operated on are finally inspected, washed with sterile salt solution, freed from underlying gauze protective pads, and dropped back fearlessly into the abdominal cavity, to assume whatever position the force of gravity and their surroundings may permit.

In adopting this method the operator has no fear that the weighty metal button will drag the bowel into a kink, or, in the case of the large intestine, that fæcal matter will choke the calibre of the canal. Nor is there any delay in the free and prompt transit of all intestinal contents.

The time required for the performance of this operation is from twenty to thirty minutes.

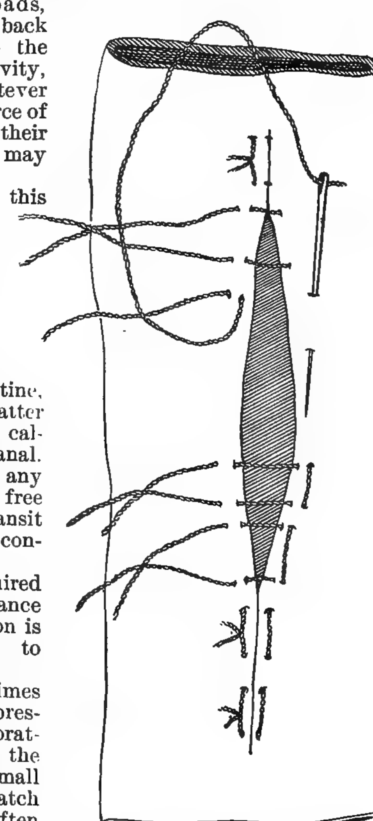

FIG. 2919.—Interrupted Suture. (Halsted.)

There are times when, in the presence of a perforating ulcer of the bowel, or of a small gangrenous patch such as is often found under the sharp edge of a strangulating hernial ring, the operator must choose between resection of a portion of the whole tube of the bowel, or inversion of the small defect by stitch. If the perforation is quite small, a purse-string, or two Lembert or Halsted stitches,

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will suffice. But when, as in the case of a gangrenous area, the patch to be removed is larger, the stitches will narrow the calibre of the bowel too much and cause obstruction by kinking. It is then that a method of stitch-

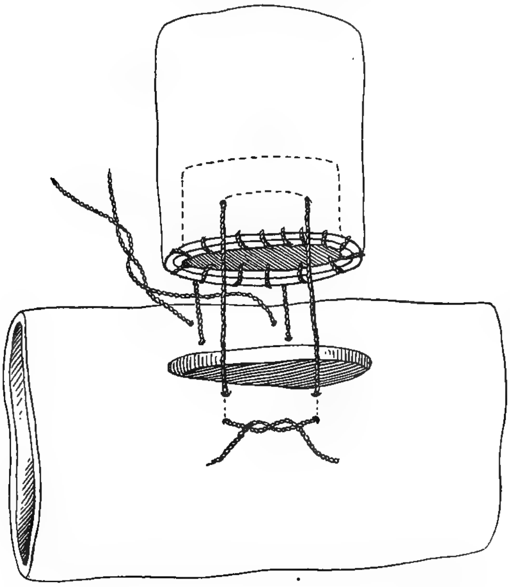

FIG. 2920.—Lateral Implantation Suture. (Senn.)

ing illustrated in Figs. 2922, 2923, and 2924, will make a perfect repair and will restore the bowel to its amplest size. When the operation is completed, the repaired part resembles the elbow-joint of a stove-pipe, and can be easily comprehended by supposing a hole in the crease at the elbow of one's coat sleeve. Now, if one closes the opening by stitches, thus drawing the elbow to a right angle, the calibre of the sleeve will be shut tightly; but if a cut is made lengthwise of the sleeve through the rent, and is extended up and down where the bent sleeve comes together and then these cut edges are sewed together as shown in the illustrations, there will be established, at the point of bending, an opening of larger

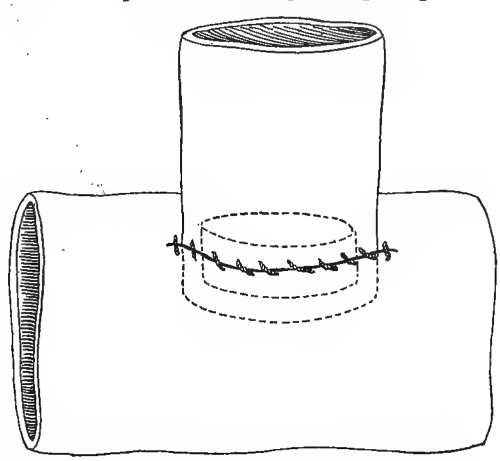

FIG. 2921.—Completed Lateral Implantation Suture. (Senn.)

diameter than that of the intestinal canal itself, and all contents will readily pass without straining the stitches or meeting obstruction.

In certain emergencies, such as impending perforation or small surface gangrene, or even when perforating ulcer has already penetrated the peritoneum, it has been proposed (Chaput) to suture this defect against the nearest adjacent bowel and let reparative lymph seal the two surfaces together. Then, if leakage does occur, the fluid cannot escape into the peritoneal cavity but is thrown back into the bowel; or, if the opposite wall gives way, the fluid contents are discharged into the adjacent intestinal canal and the small fistula between two contiguous bowels soon heals. This method of Chaput is well worth keeping prominently in mind as an operative resort which can be quickly done when time is of much importance and numerous lesions need repair. It might readily be used in gunshot perforations. The margin of the opening might be speedily sewed to the nearest piece of intestine, thus avoiding a long resection and anastomosis. Still another plan would be to resort to a kinking of the bowel by inverting a considerable portion of its surface.

Among the many devices for joining the resected bowel by mechanical aids I shall describe but three as competent to meet the operative emergency successfully. The

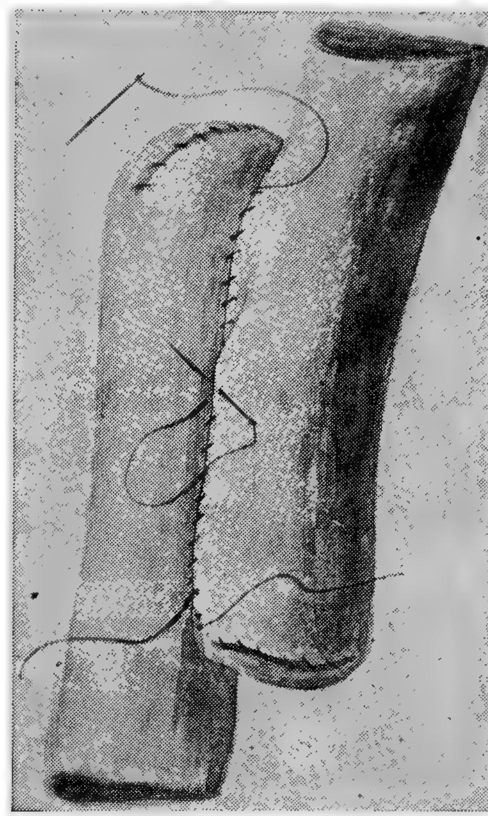

FIG. 2922.—Suturing Intestines in Apposition before Incision. Lateral anastomosis by suture (Abbe). Suturing by two rows, before incision.

first, par excellence, is that which is based upon the employment of the metal button devised by Dr. Murphy, of Chicago, and which has received recognition throughout the surgical world for its ingenuity and efficiency. It serves certain purposes better than does any other device. Thus, for example, it can be adjusted very quickly and the proper mode of using it is easily learned. It also creates an ample opening between bowels, with a narrower margin of adhesion and hence relatively little cicatricial stenosis follows its use. It has some disadvantages. Its weight has been known to drag the anastomosed loop so as to form a kink. Its hard edges have frequently produced gangrene of the wall of the bowel and temporary fistula with occasional discharge of the button through this. Occasionally the button is retained for months in the alimentary canal, but this seems to be

harmless. Occasionally the pasty contents of the lower bowel block the narrow central opening through the stem of the button and create a serious obstruction to the passage of gas. Nevertheless, for nine out of ten resections

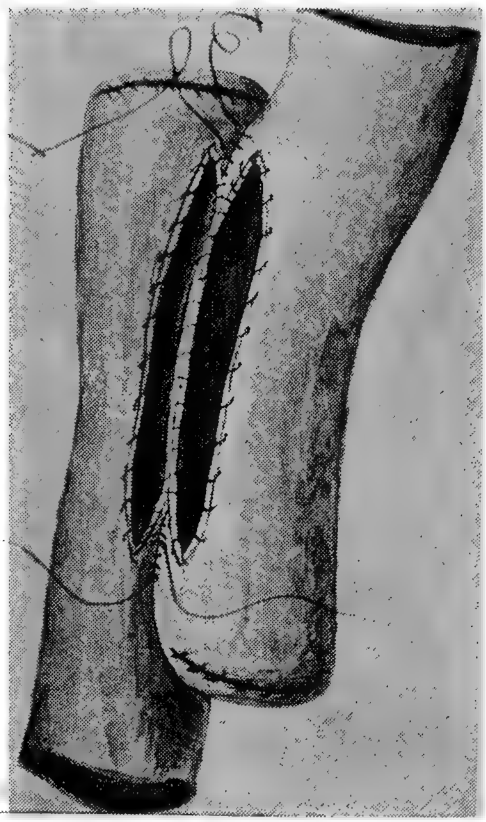

FIG. 2923.—After a Three-Inch Incision and Sewing the Edges.

of bowel the operator will find a Murphy button the most useful, indeed an almost indispensable, aid to his work. Notably in the operation for uniting the gall bladder and intestine it has completely revolutionized the judgment of surgeons as to the feasibility of establishing such a fistula in cases needing permanent drainage of bile—cases in which the common duct is completely obstructed. In this the gall bladder can be as well anastomosed to the small intestine as to the nearest presenting portion of the colon. The author prefers the latter.

The Murphy button consists of two separable halves shaped like mushrooms, the stem of one fitting into the other and secured by a spring catch. These, when joined, allow gas and liquid fæces to pass through. One half button has a separate rim bearing against the opposite one by a spring, which after adjustment confines the two imprisoned layers of bowel which have been tied around the stems, so that an immediate necrosis takes place within the rim, which sloughs away in one week, thus allowing the button to pass away free in the intestinal canal. Meanwhile natural lymph exudate at the margin of pressure has sealed the opposing peritoneal walls tightly, and a narrow line of union borders the most perfect anastomosis, with little or no subsequent tendency to contract.

The application of a strong black silk purse-string suture about the margin of the opening in such a manner that the edges of the wound will be held in close contact with the stem of the button is a detail of some nicety. Too much of the edge must not be included, as thus some excess would squeeze out round the stems when both halves are united, and thus probably lead to fouling of the peritoneum. Special care must be exercised to see that all mucous membrane of the edge must come inside the margin of pressure of the rims. Murphy claims that no suturing outside the line of pressure is needed to secure protection against infection of the peritoneum, but the author advises operators to make careful inspection and apply an extra Halsted or Lembert stitch at any point of apparent weakness or where the possibility of leakage is to be feared when the parts are returned to the cavity of the peritoneum. Indeed the utmost vigilance and carefulness are called for in intestinal surgery if the patient's life is to be saved.

Another very useful device is the bone bobbin of Mayo Robson. It serves perfectly the purpose of a frame over which the divided ends of the intestine may be united by sutures. In the earliest attempts to solve this problem cylinders of dried ox trachea or of some vegetable material were tried, but they were all found to lack durability and strength. Following the device of Senn's decalcified bone plates, Mr. Robson adapted the idea to a cylinder with admirable effect. The suitable-sized bone of an ox is immersed for twenty-four hours in a ten-per-cent. solu-

FIG. 2924.—Completed Lateral Anastomosis. (Abbe.)

tion of hydrochloric acid, which completely decalcifies it so that it may be shaped by a pen-knife to the proper form of a cylinder an inch or an inch and a half long with a furrow about its centre into which the sutured edges of the bowel may sink and thus secure the bobbin

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from slipping up or down. The ends of the cylinder should taper slightly, in order to prevent necrosis from pressure against the wall of the bowel, and the calibre

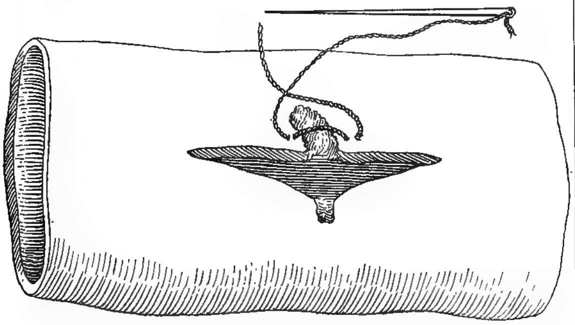

FIG. 2925.—Lengthwise Incision through Gangrenous Opening in Bowel and First Stitch. (Abbe.)

of the tube should be as large as is consistent with the required degree of strength, in order to prevent any blockade of intestinal contents. A brief immersion in

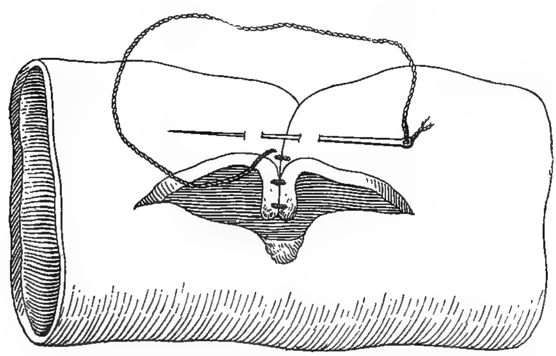

FIG. 2926.—Same. Progressive Inversion by Stitches.

soda solution, just before the time when the cylinder is about to be used, neutralizes the remnant of acid in the bone.

This bone cylinder dissolves by natural digestion in the intestinal fluids in from two to five days; *i.e.*, it re-

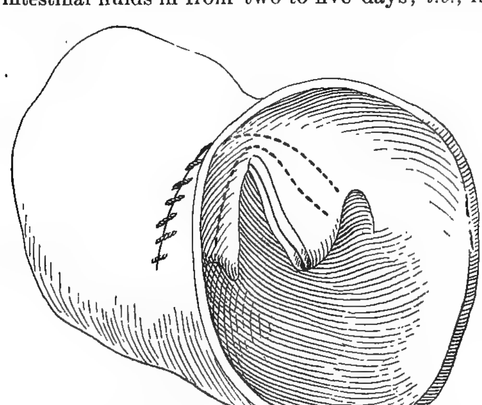

FIG. 2927.—Complete Restoration of Canal by Elbow of Bowel. (Abbe.)

tains its solidity for a sufficient length of time, and then disappears altogether. In gastro-intestinal anastomosis it is digested a little sooner than lower down, but remains firm and useful for a sufficient length of time. The continuous Lembert or Cushing suture of silk is used to join the serous edges, and to confine the bobbin, and the anastomosis can be done quickly.

Recently a device of McGraw has been added to the surgeon's armamentarium. The object of this is to do away with the necessity of making two long incisions in the bowel at points which are opposite to each other. McGraw's plan is based upon the employment of a round india-rubber ligature, 2 mm. in diameter and tapering at the end to such a degree that it may be threaded into a large needle. The latter, when thus threaded with the rubber ligature, is introduced by him through the walls of the intestine and out again at two points, corresponding to the ends of the proposed line of junction. The rubber is drawn after the needle and, through the effect of stretching, its diameter then materially diminishes, but afterward, when the stretching ceases, the cord resumes its full diameter and fills tightly the holes through which it has been passed. The operation is completed by repeating this puncture on the opposite bowel and tying the elastic ligature tightly. Thus the two lines of proposed anastomosis opening are tightly confined in the bite of the elastic ligatures, which cut through in a few days and are cast off into the bowel, but only after a channel between the two portions of the intestine has been completely established. Meanwhile reparative lymph seals the opposite surfaces of the intestinal peritoneum together and no leakage occurs during the process. This is practically the quickest method yet devised, and awaits further indorsement after a fair trial by the profession. Thus far, the few cases in which it has been used have given exceptionally fine results.

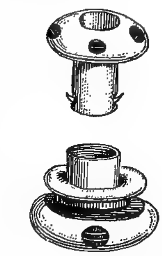

FIG. 2928.—Murphy Button. Lower part larger, as modified by Lilienthal.

In all work of a surgical character upon the intestines it is a cardinal principle that, whenever this is possible, it should be done outside the abdominal cavity; that is, when the involved part is isolated, it must be raised as far as possible and packed about with sterilized hot towels, or gauze pads (about six by twelve inches, each with its tape sewed to it hanging out of the wound with a clamp attached) placed so as to exclude the peritoneal cavity from possible soiling. The author has long been in the habit of having hot folded towels, taken from a steam sterilizer or wrung out of very hot water, frequently placed in the epigastrium during operation, and he regards the sustaining and stimulating effect on the solar plexus as of signal value, and it in no way interferes

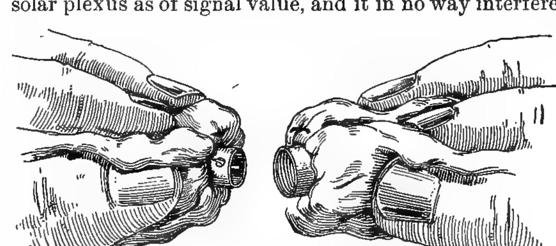

FIG. 2929.—Buttons Tied into Intestine, Ready to be Joined.

with the procedure of work. After the work of repair has been completed the parts are to be rinsed with warm saline solution, the packing is to be removed, and every part restored to its normal relations.

If the operator is satisfied with his work, it is far better to close the abdominal wound after drawing the omentum over the bowel than to place a drain in the cavity with the view of anticipating possible leakage; but if he has reason to believe that leakage may occur, he had best put a rubber or glass drainage tube in the immediate vicinity of the parts operated upon, leaving it there, however, for only two or three days.

It is not wise to apply packing of iodoform gauze over the surface of small intestines, inasmuch as fixation by lymph and the establishment of a blockade by kinking are likely to occur. This principle does not apply to the colon, however, upon which packing may freely be applied.

The after-care of cases of intestinal surgery is important and includes light fluid diet for four days, enemata every day, copious draughts of water or nutritious broths, gentle calomel action (gr. $\frac{1}{4}$ every quarter of an hour for six doses) on the morning of the third day. The author has made it a rule, in these cases, never to give salts after calomel—or indeed at any time soon after the operation—for the reason that no purgative is so likely to be repelled by the stomach; and if a reverse peristaltic action is initiated in vomiting, any natural downward peristalsis which is proceeding in the intestines will also be reversed and the wholesome relief of gas and intestinal contents will be abruptly arrested.

The following very brief review of the operations on intestines and maladies for which they will be required will aid the reader to comprehend the whole.

Enterotomy, or simple incision into the bowel, may be needed, first, to relieve accumulated gas, confined by stricture, kink, volvulus, or hernia; second, to remove an enterolith or foreign body held in the intestine (usually by stricture, due to the long detention in the bowel). In such an event a linear incision should be made in the intestine, just at the upper part of the foreign body. The latter is then worked back to the opening and removed, after which sutures are more safely applied than if the cut were made at the point of stricture. For gas distention or fæcal accumulation an incision can generally be sewed up tightly after evacuation. The parts are then rinsed and dropped back into the abdominal cavity. If relief is difficult, owing to arrest of peristalsis, there is little to be hoped for from evacuating gas, as the paralysis of the intestinal coats due to septic poison practically disables them from resuming their function.

If a gangrenous loop of bowel is resected and the patient's condition warrants it, anastomosis by Murphy button, thorough cleansing of the neighborhood and of the pelvis by pads wet with salt solution, will give the best results.

If the patient is in bad condition, an artificial anus is temporarily established by simple enterotomy.

Enterostomy, or permanent drainage of the small intestine, is a most undesirable procedure. A lateral anastomosis with a neighboring coil, or with the colon, should be preferred if the malignant growth, for example, cannot be removed safely and one must simply circumvent the obstruction. Simple suture may be ample for small ulcers, stab wounds, or perforations, but for larger ulcers one may be obliged to do the elbow suture, described above, or stitch the rent to a neighboring sound bowel surface; or use a button anastomosis.

In typhoid perforating ulcer the author has tried a variety of operative methods, and is disposed to advise putting a small button into the fistula and anastomosing it to a near-by part of the caput coli or ascending colon. This advice is given, first, because the ulcer is generally located within a foot or a foot and a half of the ileo-cæcal valve, and consequently no serious amount of intestine would be put out of commission. In the next place, there would be easy and certain discharge of gas and intestinal contents into the colon. Third, it leaves the operator the greatest liberty to wash out the abdominal cavity thoroughly with salt solution and close it by strapping without sutures, after drawing the omentum well down over the intestines and laying iodoform gauze between the edges of the wound and upon the omentum. A pelvic drainage tube is advisable but not always essential. Avoidance of abdominal wall sutures diminishes the likelihood of secondary infection cultures around the anæmic areas held tightly by the suture, at which points, in the author's experience, sepsis is apt to reoriginate.

Anastomosis.—"End-to-end" or "lateral" will be required when resection has to be done: first, to remove a malignant or non-malignant stricture; second, to circumvent an inoperable stricture; third, after resection for gangrene, for laceration, or for large perforations.

Robert Abbe.

INTESTINES, HISTOLOGY OF.—The layers recognized in a typical section of the intestinal tract (see Fig. 2934) are as follows, named from within outward:

- Mucosa (Mucous Membrane).
  - Epithelium.
  - Tunica Propria.
  - Muscularis Mucosæ.
- Submucosa.
- Muscularis.
  - Circular Layer.
  - Longitudinal Layer.
- Serosa.
  - Subserosa.
  - Endothelium.

The *epithelium* lining the intestinal tract and its glands and covering its villi and valves is derived from the entoderm, or inner germ layer. It is the only portion so derived, the much more conspicuous remaining layers arising from the mesoderm.

The epithelium consists throughout the intestines of a single layer of columnar cells. They have distinct cell walls, and on their free extremities a thickened end-plate, with fine striations parallel with the long axis of the cell. In sections the end-plates appear to be continuous from cell to cell, forming a cuticular border, varying in prominence in different sections. It is lacking in the glands and crypts. There are no cilia.

The rounded nucleus of the epithelial cell is placed nearer the deeper than the superficial end of the cell and divides the protoplasm into supranuclear and infranuclear portions. These differ geatly in function, and at times differ greatly in appearance. Cell division (mitosis) occurs only in the deeper portions of the crypts, and the cells here formed move to the more superficial regions and up on to the villi, so that tips of the villi bear the oldest cells.

Mucus appears in the supranuclear portions of the epithelial cells—probably it may appear in any—in the form of small vacuoles, which increase in size or fuse. Further increase of the mucus causes the cell to bulge laterally at the expense of its neighbors, and gives it its characteristic shape and name—"goblet cell." The protoplasm and nucleus are pushed down and the nucleus becomes flattened or triangular. The free border of the cell bulges into the lumen of the gland or of the intestine, and finally perforates through a well-defined, circular opening. The cell then shrinks into a narrow, deeply stained, rod-like structure, and probably at last resumes its original appearance. The goblet cells are easily recognized by their shape and by their staining, as the mucus generally takes a color different from that of the protoplasm, the color differing with different stains. The number of goblet cells differs in different parts of the intestine and varies with the stage of digestion.

Leucocytes are often observed between the epithelial cells. They are recognized by the smaller size and deeper staining of the nucleus compared with that of the epithelial cell. The nucleus is usually surrounded by a pale halo, representing the protoplasm. According to Stöhr they are in the act of wandering into the lumen of the intestine.

The intestinal glands or crypts of Lieberkühn are found in all parts of the intestine. They are simple tubular glands, seldom branching. They extend nearly down to the muscularis mucosæ. Goblet cells are present except in the extreme fundi. Evidences of cell division are present, as has already been said, in their deeper portions, and where it occurs the nuclei move nearer to the exposed ends of the cells and out of the row formed by the other nuclei. They differ but slightly in different regions of the intestines.

Beneath the epithelium there is a basement membrane, upon which the cells rest. Opinions as to its structure and significance differ.

The *tunica propria* throughout the intestines consists of typical reticular tissue containing lymph cells. Mall describes three kinds of fibres found in the various forms of connective tissue—white, fibrillated fibres, yellow elastic fibres, and reticulum fibres. He shows that the mucous membrane of the intestine contains none of the elastic structures, and but few of the white fibrils. The reticulum is, however, unusually well developed. In the tunica propria are found numerous capillaries, some of whose branches make networks about the glands and in the villi; lymph spaces, and smooth muscle fibres derived from the muscularis mucosæ. There are also numerous leucocytes, particularly lymphocytes. These are in some places collected into masses, forming the Peyer's patches and solitary nodules, presently to be described.

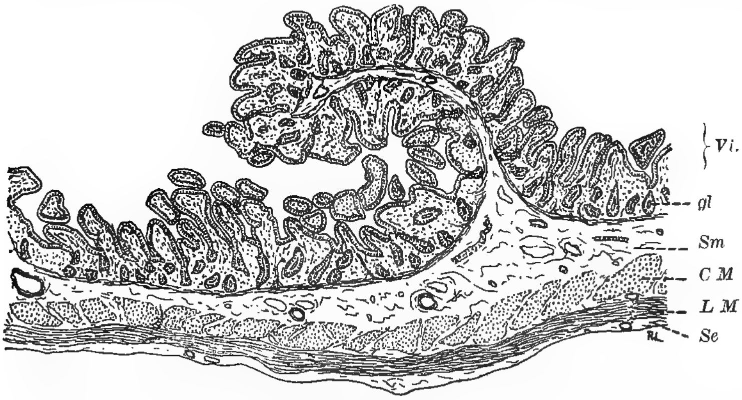

FIG. 2930.—Small Intestine. Longitudinal Section of Wall of Human Jejunum, showing One of the Valvulæ Conniventes. (From author's own drawing.) *Vi*, Villi; *gl*, glands or crypts of Lieberkühn; *Sm*, submucosa; *C M*, circular muscle layer; *L M*, longitudinal muscle layer; *Se*, serosa.

The *muscularis mucosæ* consists of a delicate sheath of non-striated muscle fibres, lying between the tunica propria and the submucosa. The fibres are arranged in two layers like those of the muscularis proper—an inner circular and an outer longitudinal. Fibres branch off from the muscularis mucosæ and run up between the glands and into the villi. The function of this layer is to compress the mucous membrane and thus aid the passage of fluids through it.

The *submucosa* is a wide layer of loose areolar connective tissue. The elastic network is fairly well developed. The layer contains numerous blood-vessels, and through it must also pass nerve fibres and lymphatics. Fat cells are often observed.

The *muscularis* is composed of involuntary or smooth fibres arranged in two compact sheets or layers. The inner layer has its fibres arranged circularly about the lumen of the intestine. The outer layer is composed of fibres running longitudinally. The proportionate thickness of the two layers varies but little. The circular sheath is much the thicker, as the drawings illustrating this article show. The arrangement of the muscular layers is essentially alike throughout the intestine. It is evident that by observing the direction of the fibres we can always tell the direction in which a given section was cut. Thus a section parallel to the long axis of the intestine always cuts the fibres of the outer layer of muscles longitudinally and those of the inner layer across. A section cut across the lumen of the intestinal tube always shows an inner layer of muscle fibres cut longitudinally and an outer layer cut across.

The *serosa* is the outermost layer. In consists of a thin sheet of connective tissue, the subserosa, separating the peritoneal endothelium from the outer muscular layer. The peritoneal endothelium consists of a single layer of greatly flattened cells, so thin that in cross sections under ordinary powers of the microscope they appear like slender lines in which the nuclei are bulging dots. In cross sections it will be seen that where the intestinal tube is attached to the mesentery, the peritoneal later is continued over on to the latter, while the subserous connective tissue is thickened and continuous with the connective tissue of the mesentery and with the adventitia of the vessels entering and leaving the intestine at this point. The peritoneal endothelium is of course lacking over portions of the intestinal tube, where the latter is attached directly to the abdominal wall, without mesentery, as in the ascending and descending colon, the duodenum and the rectum.

THE SMALL INTESTINE.—This part of the alimentary canal is characterized by the presence of villi. These are found nowhere else in the intestinal tract.

Villi are finger-like projections of the mucous membrane into the lumen of the intestine, involving the epithelium and tunica propria (see Figs. 2930, 2933, and 2931). They are about a millimetre high. The inner surface of the intestinal canal is thickly studded with them all the way from the pylorus to the ileo-cæcal valve. They are so numerous that hardened specimens have the appearance of velvet. Their number has been

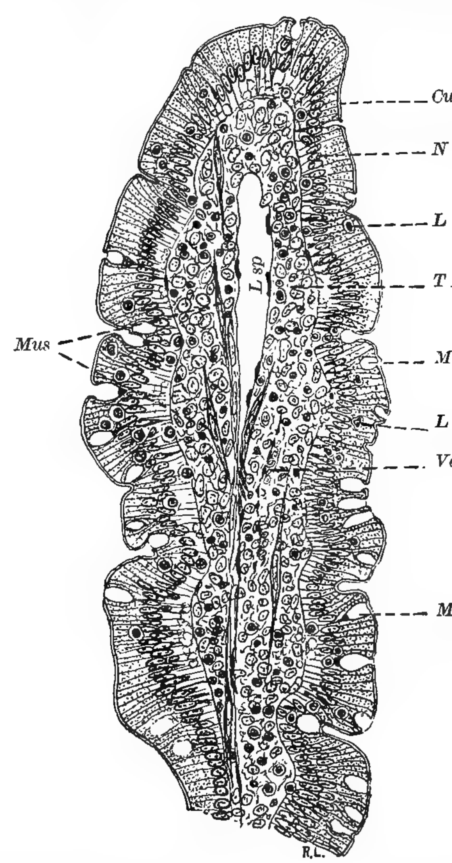

FIG. 2931.—Villus from Small Intestine of Java Monkey, showing Dilated Central Lymph Space (*L sp*). (From author's own drawing.) *Cu*, Cuticular border of epithelial cells; *N e*, nucleus of epithelial cell; *L*, lymphocytes; *T P*, tunica propria; *M*, mucous cells; *Ves*, blood-vessel; *Mus*, smooth muscle fibres; *L sp*, central lymph space.

estimated at four millions. Obviously, by their means the absorbing surface is enormously increased.

The villus is covered with epithelium continuous with the general epithelium of the intestine. In the cells fat

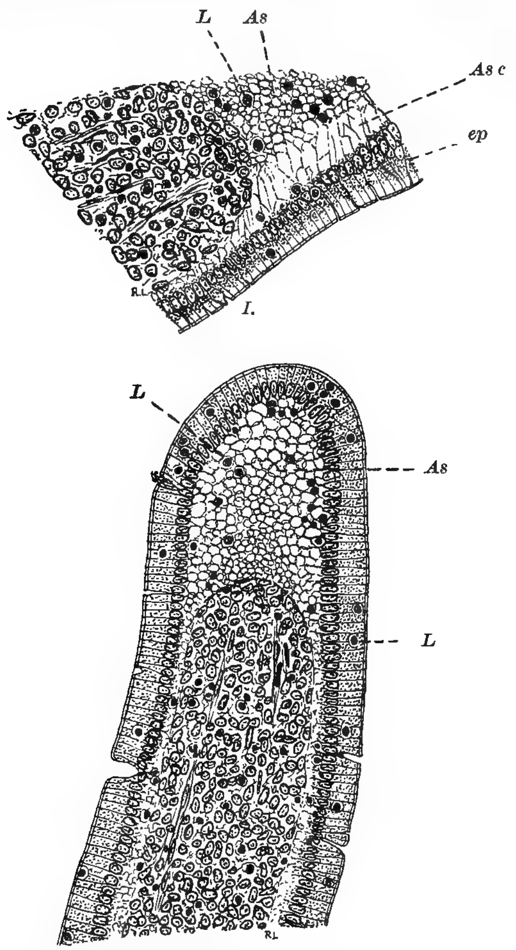

FIG. 2932.—Portions of Villi from Cat's Intestine, showing Stages of Absorption. (From author's own drawings.) I., Earlier stage. II., Later stage. *As*, Absorbed material occupying the end of the villus in the form of spherules; *As c*, the same, occupying the inner ends of epithelial cells not yet entirely destroyed; *L*, lymphocytes; *ep*, epithelium. (The spherules are here exaggerated in prominence. In the specimen they were but faintly colored.)

droplets are often recognized. Goblet cells are numerous and leucocytes are seen wandering through between the cells. They are especially numerous during digestion. The mass of the villus is made up of reticular connective tissue continuous with that of the tunica propria. The centre is occupied by a lymph space or lacteal, lined by exceedingly delicate endothelium. There are occasionally two intercommunicating lymph spaces. In the space between the lacteal and the epithelium, covering the villus, lie a few smooth muscle fibres derived from the muscularis mucosæ, and numerous capillaries. The muscle fibres are disposed in a direction in the main parallel to the long axis of the villus. By their contraction the villus is compressed and the central lymph space emptied of its absorbed lymph. Re-expansion of the villus so contracted is accomplished by the capillaries, which when distended cause an erection of the villus to its original proportions. The capillaries form a dense network immediately beneath the epithelium. The blood entering the villus and leaving it, occupies larger vessels more deeply situated.

Favorable sections of the small intestine often show the reticular tissue forming the axis of the villus to be separated from the epithelium, especially near its tip, by a considerable space. This has ordinarily been considered an artefact, and is so labelled in one of our best text-books of histology. Careful inspection, however, shows that the space is occupied by faintly stained circles or spherules resembling a section of foam. Moreover, the infranuclear portions of the epithelial cells are poorly marked or missing, while the reticular tissue is sharply outlined as if the basement membrane had pulled away with it. According to Mingazzini, these appearances are due to the absorption of food material by the epithelial cells. Such material is stored in the infranuclear portions of the cells in the form of spherules, which ultimately cause that end of the cell to break down, leaving a space just beneath the epithelium filled with the spherules. For a time cell outlines are preserved, and in favorable specimens are not difficult to see (Fig. 2932, I).

The villi, then, are decidedly complicated structures. Their presence enables us to recognize at once a specimen of the small intestine when seen in section, and to distinguish it from other parts of the bowel.

The different portions of the small intestine—the duodenum, jejunum, and ileum—differ histologically from one another only in detail.

The *duodenum* is characterized by the presence, along with the simple crypts, of *Brunner's glands*. These, in marked distinction from the simple intestinal crypts, are situated chiefly below the muscularis mucosæ in the submucosa, from which the ducts lead up through the tunica propria to empty into the crypts or at the bases of the villi. The glands are of the branched, alveolar type. Their cells closely resemble those of the pyloric glands of the stomach. Moreover, as they show certain changes during digestion, it is probable that they secrete a digestive fluid. Their appearance is shown in Fig. 2933. They are most numerous in the upper portion of

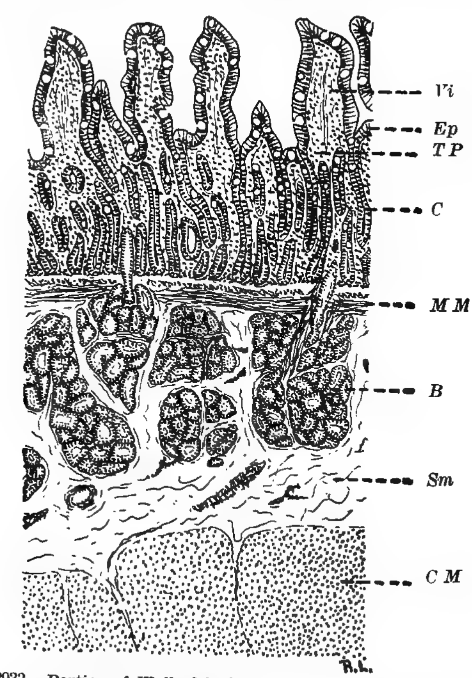

FIG. 2933.—Portion of Wall of Cat's Duodenum. (From author's own drawing.) *Vi*, Villus; *ep*, epithelium; *T P*, tunica propria; *C*, crypt; *M M*, muscularis mucosæ; *B*, Brunner's glands; *Sm*, submucosa; *C M*, circular muscle layer.

the duodenum. This part of the intestine is further characterized by the shortness of its villi and by the presence, in its lower part, of valvulæ conniventes, more characteristic of the jejunum.

At the upper end of the duodenum a few gastric pits,

like those of the pylorus, are found, while in the same region the crypts are poorly developed. In other words, the change from pylorus to duodenum is not, so far as the mucous membrane is concerned, abrupt.

The *jejunum* and *ileum* present no striking differences from one another. We may say, however, that in the

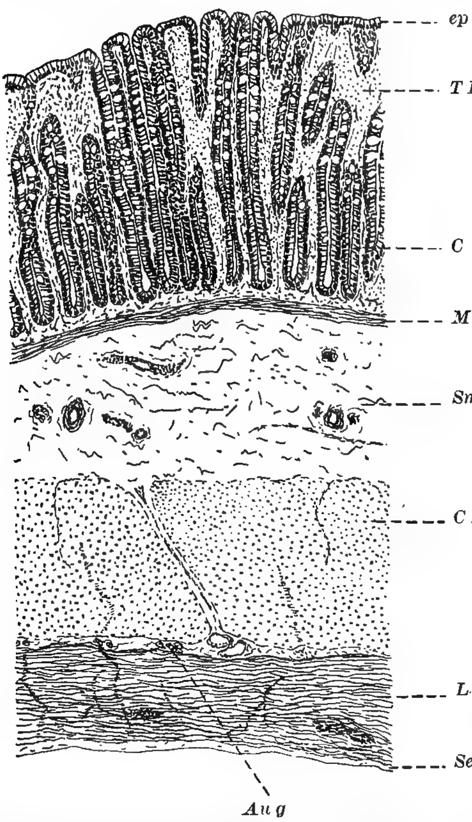

FIG. 2934.—Large Intestine of Cat. (From author's own drawing.) *Ep*, Epithelium; *T P*, tunica propria; *C*, crypts of Lieberkühn; *M M*, muscularis mucosæ; *Sm*, submucosa; *C M*, circular muscle layer; *L M*, longitudinal muscle layer; *Se*, serosa; *Au g*, ganglion of Auerbach's plexus.

case of each, peculiar structures may dominate the histological picture, viz., the valvulæ conniventes in the jejunum, and the Peyer's patches in the ileum. *Valvulæ conniventes* or plicæ circulares are folds involving the mucous membrane and the submucosa, and partly surrounding the lumen of the intestine (see Fig. 2930). They make, as it were crescentic shelves. They are especially numerous in the lower duodenum and jejunum. The patches of Peyer will be discussed below. The villi of the jejunum are longer than in the duodenum, while in the ileum they are longest of all, and tend to be club-shaped. Toward the lower end of the small intestine they again decrease in length.

THE LARGE INTESTINE.—The large intestine is characterized histologically by the absence of villi. The crypts are about twice as deep as in the small intestine, and are straighter and more numerous and crowded. Their epithelium is thickly studded with goblet cells, especially near their mouths, much more so than in the small intestine. According to Stöhr, this is due to the fact that the movements of the epithelium from the depths of the glands, where active proliferation takes place in the cells, are slower than in the small intestine where the new cells have to travel clear to the tops of the villi. As the distance to be travelled is less than in the small intestine, the goblet cells have more time to develop and appear thicker and more numerous. The tunica propria, owing to the greater number of crypts, is less extensive than in the small intestine. It contains muscle fibres. The muscularis mucosæ and the submucosa are similar to the same structures in the small intestine. The longitudinal muscle fibres, except in the rectum and appendix, are strengthened in three places in the circumference into flattened longitudinal bands—posterior, anterior, and inferior. As these are somewhat contracted the large intestine presents the familiar sacculated appearance, due to the puckering of the intervening thinner parts of the wall. The serous layer is exactly like that of the small intestine in structure. In the ascending and descending colon there is no peritoneal epithelium on the posterior aspect. The serous coat of the colon is, here and there, prolonged into little pedunculated tabs, filled with fat and called "appendices epiploicæ."

The *vermiform appendix* has a structure essentially like that of the large intestine. It has the same arrangement of serous and muscular layers. The mucous membrane surrounding the relatively small lumen is thrown into folds, as is shown in Fig. 2935. The mucous membrane has, like other parts of the large intestine, abundant crypts, but no villi. The most marked feature is the large number of lymphoid nodules. These are so numerous that the appendix might appropriately be described as a Peyer's patch. The bearing of this on typhoid fever and appendicitis is obvious and is not always appreciated by clinicians.

In many individuals the lumen of the appendix is found to be obliterated. The mucous membrane has almost or entirely disappeared, and is replaced by fat, the centre of the organ being occupied by a cord of connective tissue. Zuckerkandl found this condition in nearly a fourth of the cases examined. Though it would be natural to attribute it to senile degenerative changes or to slight or

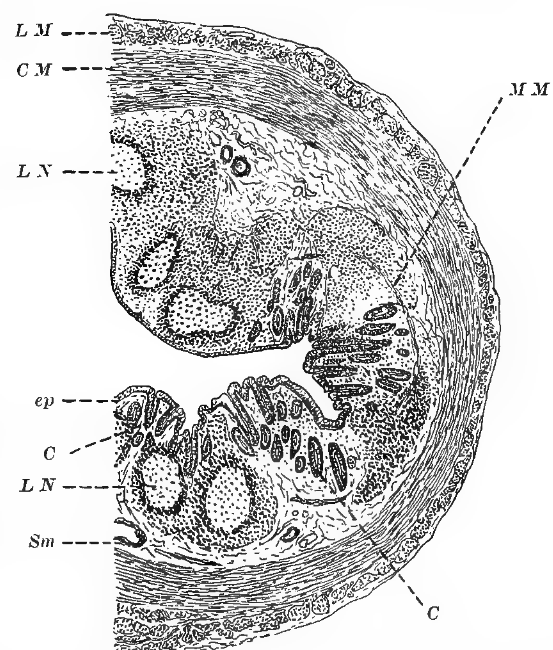

FIG. 2935.—Vermiform Appendix, Human. (From author's own drawing.) *L M*. Longitudinal muscle layer; *C M*, circular muscle layer; *L N*, germ centre of lymph nodule; *ep*, epithelium; *C*, crypts of Lieberkühn; *Sm*, submucosa; *M M*, muscularis mucosæ.

forgotten attacks of appendicitis, both Zuckerkandl and Ribbert consider it to be a normal process taking place in an organ that has become functionless.

At the ileo-cæcal valve, where the cæcum begins and the ileum ends, there is a somewhat complicated arrangement of the mucous membrane. Even above the ileum

the villi are short and their bases tend to fuse into a honeycomb structure. This persists for a short distance on the cæcal side of the valve, together with a few villi.

Lymphoid tissue is found in the tunica propria of all parts of the intestine. It consists of small masses, called follicles or nodules, like those found in the peripheral parts of the lymphatic glands (see article *Connective Tissue*). In the duodenum, jejunum, and upper ileum they are relatively scarce. In the lower ileum they are present in the form of *Peyer's patches.* These are aggregations of lymph nodules. They are from one-half to two inches long by half as wide. They are longitudinally placed, on the part of the intestine away from its mesenteric attachment. The patches ordinarily number about twenty to thirty. In old age they are prone to undergo atrophy.

Each Peyer's patch consists of from ten to sixty nodules. In each nodule a germ centre may be recognized by the fact that here the nuclei are less crowded and take the basic stain more faintly. Evidences of karyokinesis are here found. The nodules are described as "breeding-places" for lymphoid cells, and it is in the germ centres that active cell division occurs. The young lymphocytes so formed either pass into the surrounding lymph vessels or, according to Stöhr, wander through the epithelium, into the lumen of the intestine. The nodules may run together into a mass of lymphoid tissue. As elsewhere in the intestine, the lymphoid tissue of the Peyer's patch lies primarily in the tunica propria, but it encroaches on the submucosa, reaching nearly down to the circular muscle layer. The muscularis mucosæ in such cases is interrupted. Villi are commonly lacking over the nodules; or the lymphoid tissue causes the villi to bulge, as it were; and consequently at such points this tissue projects into the lumen of the gut (see Fig. 2936). Over such projecting nodules the epithelium contains an unusual number of leucocytes.

In the large intestine, particularly in the appendix, as already stated, solitary follicles or nodules are very numerous and usually have germ centres. Over them the crypts are rudimentary or wanting. The nodules generally break through the muscularis mucosæ and lie partly in the submucosa. In man the solitary nodules make but slight depressions in the general level of the mucous membrane, but in some animals they lie at the bottom of deep depressions. Over the tops of the nodules the epithelium may appear to lose its basement membrane so that the cells are in closer relation to the reticular tissue.

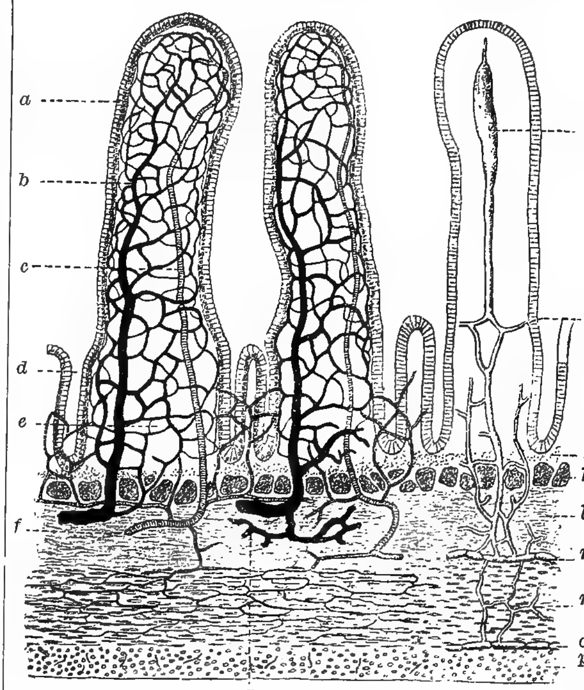

FIG. 2937.—Diagrammatic Cross Section of the Small Intestine of the Human Being. (From Böhm and Davidoff.) *a*, Epithelium of the villus: *b*, vein, and *c*, artery of the villus; *d*, intestinal gland: *e*, base of the villus; *f*, artery; *g*, vein; *h*, central chylous radicle of the villus; *i*, chylous vessel; *j*, tunica propria; *k*, muscularis mucosæ; *l*, submucosa; *m*, plexus of lymphatic vessels; *n*, circular muscular layer; *o*, plexus of lymphatic vessels; *p*, longitudinal muscular layer and serosa.

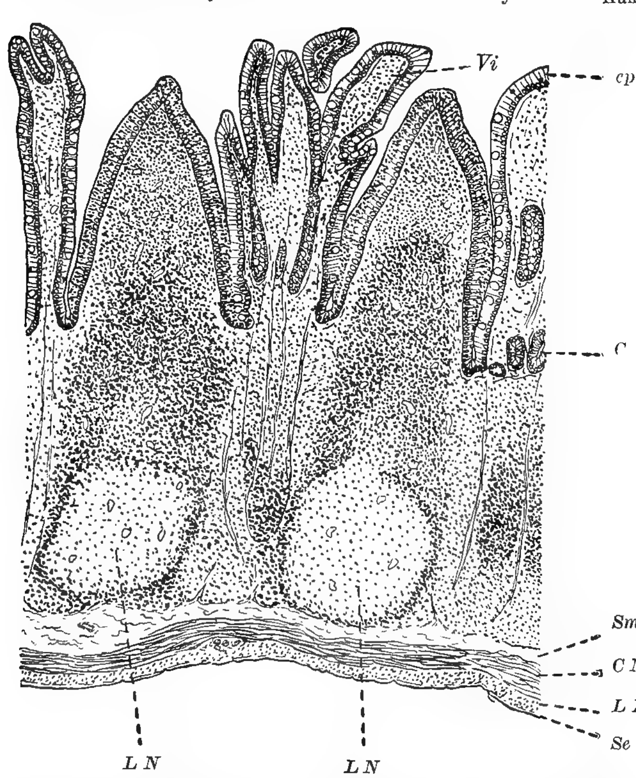

FIG. 2936.—Part of a Peyer's Patch from Cat's Intestine. (From author's own drawing.) *Vi*, Villus; *ep*, epithelium; *C*, crypt of Lieberkühn; *Sm*, submucosa; *C M*, circular muscle layer; *L M*, longitudinal muscle layer; *Se*, serosa; *L N*, germ centre of lymph nodule.

Blood-vessels.—Arteries enter the intestinal wall at its mesenteric attachment. The larger branches lie in the submucosa. The muscular and serous layers are supplied by the vessels in the submucosa and by branches from the main arteries as they pass through the muscular layers. From the submucosa numerous small branches pass through the muscularis mucosæ and feed an abundant network of capillaries lying below and about the glands and bring to them the materials from which their secretions are elaborated. Small branches also enter the villi. These enter the villus from below, lying near its centre, and give off numerous capillaries which make an abundant anastomosing network just under the epithelium. They drain into small venules which like the arterioles lie near the central axis, and finally lead into the venous plexus in the tunica propria. The larger veins run along with the arteries. The lymph nodules are surrounded by a fine network of capillaries from which branches enter the nodules. The centres of the latter, however, are often bloodless.

The lymphatics of the intestine will be described in detail in the article *Lymphatic System*. In ordinary histological sections we see, in favorable cases, the lymph space in the centre of the villus, and the evidences of absorption already described. Further than this the only factors which the lymph channels introduce into the histological picture of ordinary specimens is the occasional section of a lymph space in the submucosa and peculiar appearances in the muscular layers where a lymphatic passes through them. This appearance is indicated in Fig. 2934. It is due to the fact that the muscle fibres are pushed a little aside by the vessel passing between them and the direction of section of these fibres is thus changed.

Nerves.—The intestine is supplied from the abdominal sympathetic system by non-medullated fibres which enter at the mesenteric attachment. In the wall of the gut are situated two nervous plexuses. These are the plexus of Auerbach or plexus myentericus, and the plexus of Meissner. They communicate with the entering fibrils from the sympathetic. The plexus of Auerbach is between the two muscle layers (see Fig. 2934). Numerous ganglia consisting of collections of large multipolar nerve cells are united by bundles of non-medullated nerve fibres into a conspicuous network. There are a few medullated fibres. If we macerate and strip the muscle layers from the submucosa, and stain them by the gold process, we get the beautiful picture shown in Fig. 2938. In sections stained by any of the ordinary methods the ganglia may be easily found (Fig. 2939). The cells are characteristically large, irregular in shape, with deeply stained protoplasm and no cell wall. The nuclei are large, round or oval, vesicular in staining and have usually single, large nucleoli. The cells have dendrites which branch and ramify in the ganglia and extend even into the nerve bundles. Their axons form the bundles of non-medullated fibres uniting the ganglia, extending into the muscular layers, repeatedly dividing and branching there and finally ending on the smooth muscle cells. The plexus of Meissner is much less conspicuous. It forms a network like that of the plexus of Auerbach, but much more delicate. It lies in the muscularis mucosæ. It anastomoses freely with the plexus of Auerbach, and non-medullated fibres pass into the muscularis mucosæ, into the tunica propria, and probably to the gland cells of the epithelium. *Ralph C. Larrabee.*

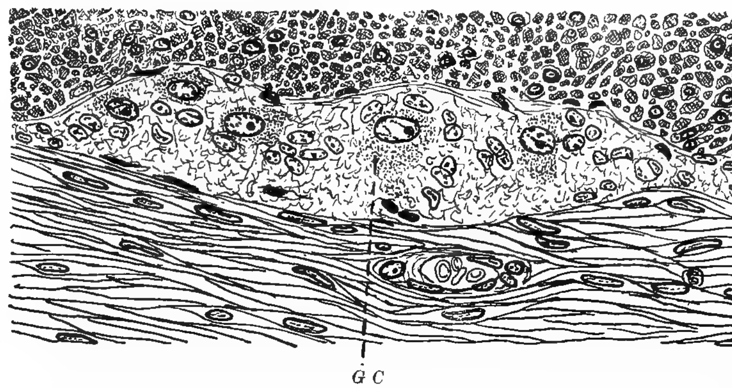

FIG. 2939.—Group of Ganglion Cells of Auerbach's Plexus in Human Small Intestine. (From author's own drawing.) *G C*, Ganglion cell; *C M*, circular muscle layer; *L M*, longitudinal muscle layer.

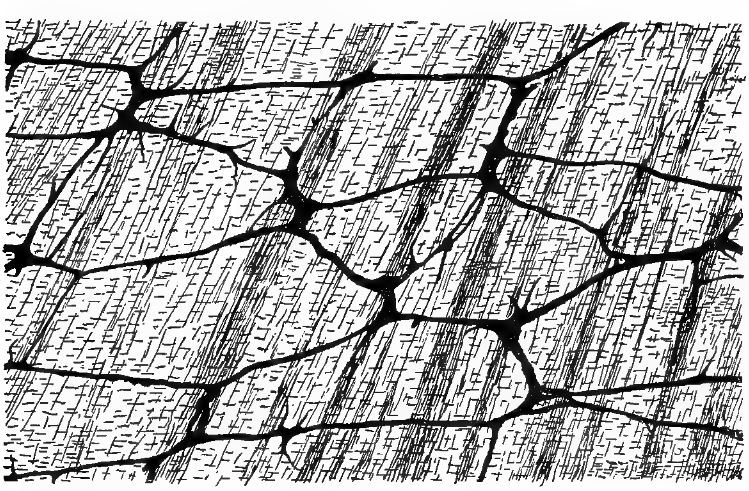

FIG. 2938.—Auerbach's Plexus from Small Intestine of Rabbit. Chloride-of-gold preparation. (From author's own drawing.)

INTESTINES, INFLAMMATION OF. See *Colitis; Dysentery;* and *Enteritis.*

INTESTINES, INJURIES OF. See *Abdomen. (Surgical.)*

INTESTINES, NEW GROWTHS OF.—If we adopt the embryological basis of classification [1] we may say that the following primary new growths occur in the intestines:

I. *Tumors derived from the ectoderm.*
(*a*) From the epidermis.
1. Epidermoid carcinoma.

II. *Tumors derived from the entoderm.*
1. Adenoma.
2. Carcinoma.

III. *Tumors derived from the mesoderm.*
(*a*) From the mesenchyma.
1. Sarcoma.
2. Fibroma.
3. Leiomyoma.
4. Lipoma.
5. Angioma.
(*b*) From the mesamœboids.
1. Lymphosarcoma (pseudo-leukæmia).
2. Leukæmia (lymphatic).

PATHOLOGICAL ANATOMY.—There occur tumor-like structures that perhaps are best regarded as forms of *hypertrophy* of the mucous membrane. They are present in so-called chronic catarrh and in the neighborhood of the chronic ulcerative processes in dysentery and tuberculosis. They are polypoid structures in which the glandular constituents usually predominate. They also occur apparently quite independently of any inflammatory process, even as early as the third year, and are then commonly called *mucous polyps*. They project into the lumen of the intestine and may be as large as a pigeon's egg. When they occur in the region of the anus they may prolapse, and eventually cause prolapse of the mucous membrane also.

When the arrangement and structure of the glands

differ considerably from the normal the growths are perhaps best designated as *polypoid adenomata*. There are transitional forms that may be regarded either as results of hypertrophy or as tumors.

Adenomata not conspicuously elevated above the surface occur, especially in the rectum, usually immediately above the epidermis.

The *carcinomata* constitute the most important group of new growths. With the exception of the epidermoid carcinoma occurring at the anus, the fundamental form of most of these is the cylindrical-cell adenocarcinoma. They are commonly annular in form. It is believed that they may originate from primarily benign adenomata. They may be fungoid or otherwise circumscribed in form, or they may diffusely infiltrate considerable areas. When infiltration is marked the wall of the intestine is thickened and indurated, and if the growth involves the whole circumference of the wall, the intestine may be converted into a stiff, thick-walled tube. This occurs especially in the rectum and colon. Ulceration begins early. Some forms are medullary, others are scirrhous. The latter may be small and scar-like in form. Contraction of the stroma of the tumor, especially in the scirrhous form, tends to bring about narrowing of the lumen of the intestine. A relatively common form, especially in the rectum, is the colloid carcinoma. It tends to involve considerable surface and to infiltrate extensively the surrounding tissues. Early ulceration leads to extensive loss of substance, especially when the stroma is soft, and in this way the lumen of the intestine may be considerably enlarged.

Metastases occur in the neighboring lymph nodes, and, at a relatively early stage, appear in the liver and in other organs. In the most common carcinomata—those of the rectum—the sacral, lumbar, and higher retroperitoneal lymph nodes are first involved. The inguinal lymph nodes are involved only when the anal region is concerned.

Carcinomata of the intestines occur most commonly in the rectum, immediately above the sphincter or in the middle region. Next in frequency they are found in the region of the ileo-cæcal valve, in the sigmoid and hepatic flexures, and at the common orifice of the pancreatic and common bile ducts in the duodenum. They are uncommon in the small intestine and here occur most frequently in the duodenum. Males appear to be more commonly affected than females. They may occur as early as the first decade, but, as a rule, they appear in advanced life. The early occurrence is possibly associated with the early appearance of adenomata previously referred to. The common occurrence in the rectum and in the flexures of the cōlon suggests a mechanical factor in the etiology. On the other hand, the lower end of the rectum is one of the places where complicated developmental processes occur.

The results of carcinoma consist primarily in narrowing of the lumen of the intestine and induration of its walls. This brings about a stasis of the contents and a widening of the lumen above the point of constriction. If the obstruction comes on gradually considerable hypertrophy of the muscular coats above also results. If it comes on acutely there is great and rapid dilatation with thinning of the wall, as a result of the sudden fæcal stasis, and death occurs before hypertrophy has developed. Occasionally, as described above, the lumen may become even wider than normal as a result of ulceration with extensive loss of substance. Perforation is most apt to occur in these cases. According to the location of the perforation, this is followed by periproctitis, localized or general peritonitis, and fistulæ leading into the rectum, vagina, colon, bladder, etc.

In the anal region of the rectum epidermoid carcinoma occurs, originating from the epidermis. This usually begins as a nodular or papillary growth, and may become annular. It tends to invade the surrounding skin more extensively than the mucous membrane. Melanotic carcinomata are said to occur occasionally.

Secondary carcinomata are common in the serosa of the intestines, but rare in the mucosa. They may arise by direct extension from the stomach, pancreas, uterus, vagina, or other abdominal organs. Implantation and metastasis perhaps also occur. Apparently any form of secondary carcinoma may be present.

Of the mesenchymal tumors *fibromata* occur in nodular and papillary forms, and are frequently polypoid. They may be as large as a pigeon's egg and may be present even in children. At the anus fibrous tags may result from hemorrhoids, and papillary fibromata in the form of moist condylomata result from gonorrhœal infection. Polypoid fibromata occur in various parts of the mucous membrane. *Lipomata* originating in the submucosa may project into the lumen in a polypoid form, and occur especially in the jejunum. *Sarcomata* are rare, but nodular spindle-cell sarcomata, as well as alveolar and melanosarcomata, and round-cell sarcomata of large size, have been described.

Fibromyomata are relatively rare. Polypoid forms may be as large as an apple.

Angiomata are extremely rare, but nodular and diffuse telangiectases and a polypoid cavernous angioma have been described. A multilocular chylangioma cysticum, as large as a goose egg, was found beneath the serosa of the ileum in a five-year-old girl. Dermoids are said to occur in the rectum.

Many of the non-carcinomatous tumors and hypertrophic growths in the mucous membrane are too small to cause any disturbance of function. The larger ones may cause obstruction and, by the aid of peristalsis, even invagination of the intestinal wall. Polypi with narrow pedicles may become free and appear in the fæces.

We may regard *pseudo-leukæmia* and *lymphatic leukæmia* as closely analogous to tumor formation. In some of these cases the lymphoid tissue of the intestine appears to be principally involved, and Peyer's patches and the lymph nodules are considerably enlarged.

Symptoms.—"In the first place, the affection may be latent, revealed at autopsy alone, or the early and indeed the chief symptoms may be due to the secondary tumors. . . . The sole objective feature may be the progressive enlargement of the liver." [4]

"The symptoms, in case of obstruction, are very diverse. Constipation gradually comes on, is extremely variable, and it may be months or even years before there is complete obstruction. There are transient attacks, in which from some cause the fæces accumulate above the stricture, the intestine becomes greatly distended, and in the swollen abdomen the coils can be seen in active peristalsis. In such attacks there may be vomiting, but it is very rarely of a fæcal character. In the majority of these cases the general health is seriously impaired; the patient gradually becomes anæmic and emaciated, and finally, in an attack in which the obstruction is complete, death occurs with all the features of acute occlusion, or the case may be prolonged for ten or twelve days." [5]

"In the diagnosis of cancer of the intestine the following points may be taken into consideration. In comparison with the subjects of malignant disease of the stomach very many of the patients are young; . intestinal features are present in a majority of cases; . . . griping, colicky pains are common, even without the signs of obstruction. With narrowing of the lumen of the gut very characteristic features occur—attacks of severe griping pain, abdominal distention, the presence of active, sometimes visible peristalsis in the distended coils of the bowel, and, if the condition persists, vomiting and all the signs of intestinal obstruction. . . . If fungous masses project and cause more or less narrowing, colicky pains and constipation are inevitable; but, on the other hand, as the tumor grows, if there is necrosis of its surface, with excavation, neither pain nor constipation may be present. Diarrhœa and the passage of much slime with the fæces are not infrequent symptoms. Hemorrhage is also common. The blood is not often in large quantities; when the tumor is in the sigmoid flexure it may be bright and very little changed, but in the growths about the cæcum

it is often much altered before it appears in the stools. There are cases in which the constant loss of small quantities of blood is a very special feature, and the patient becomes profoundly anæmic. Sloughy fragments of the tumor may sometimes be passed in the fæces.

"A cachexia develops progressively but with variable rapidity. It may, however, be well marked before any features have arisen suggestive of intestinal trouble. The loss in weight may, too, be slight, even after the tumor has persisted for many months. When extensive secondary growths develop, the cachexia may be profound. The tumor in cancer of the intestines may be readily and easily discovered—indeed, evident on inspection. On the other hand, it may not be until the terminal stage of the disease that the growth is found. A small tumor of the hepatic or splenic flexure of the colon may escape repeated examinations. Mobility is a special feature of growths in the large bowel. Large tumors, however, of the cæcum may be quite fixed. The most movable growths are those connected with the sigmoid flexure. Variability in size is also a marked character, and at one examination the mass may appear as large as the closed fist or even two fists, and the next day it appears not larger than a small apple. These variations are due largely to the presence of fæcal masses in the vicinity. Two very important features in the intestinal tumor may sometimes be detected on careful palpation—namely, the hardening during contraction of the hypertrophied wall in the vicinity of the growth, and the bubbling of gas through the tumor which may be heard as well as felt."[4]

"A thorough rectal and, in women, a vaginal examination should be made, which will give important information as to the condition of the rectal and pelvic contents."[5]

"The intestinal symptoms above referred to and a progressive cachexia are generally sufficient to warrant a diagnosis."[4]

PROGNOSIS.—In carcinoma the prognosis is bad. Before the condition is recognized secondary involvement of other organs is usually so extensive as to be beyond operative control. The local condition may, however, be completely relieved by operation, and health apparently restored for a time. *H. S. Steensland.*

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INTESTINES, PHYSIOLOGY OF. See *Absorption; Digestion;* and *Intestinal Movements.*

INTESTINES, SYPHILIS OF. See *Syphilis.*

INTESTINES, TUBERCULOSIS OF. See *Tuberculosis.*

INTESTINES, WOUNDS OF.—Intestinal wounds depend on the same causes as wounds elsewhere. The injury usually comes from without, but in rare instances the lesion is caused by a foreign body in the intestinal canal.

Each anatomical division of the intestinal tract is liable to injury, but those portions that are most extensive or most exposed are obviously in greatest danger. For these reasons the ileum and jejunum suffer most frequently, the colon occasionally, the duodenum least of all. In contusions, however, the duodenum seems to suffer a little more frequently than the colon. The latter, especially its vertical portions, has but a limited range of motion, and is, therefore, in this respect poorly protected against traumatic influences. It largely possesses, however, the immunity afforded by a deep location, comparatively limited functional activity, and dense protecting structures.

The mobility of the intestines, due to their lax attachments, the peculiar nature of their investing membranes, their elasticity, and the yielding character of the tissues about them, affords the greatest possible natural immunity from violence that is consistent with the proper performance of the functions of the human body.

While in normally developed adults the divisions of the intestine present no decided differences in their relations to the abdominal wall, yet Treves has shown it to be impossible definitely to localize any certain portion of the jejunum or ileum by external examination. In Treves' own words: "There is no systematic arrangement of the coils of the small intestine. There is a disposition for the bowel to follow an irregularly curved course from left to right, but this disposition can never be relied on. Such as it is, it may be expressed as follows: The gut starting from the duodenum will first occupy the contiguous parts of the left side of the epigastric and umbilical regions. The coils then fill some part of the left hypochondriac and lumbar regions. They now commonly descend into the pelvis, reappear in the left iliac quarter, and then occupy in order the hypogastric, lower umbilical, right lumbar, and right iliac regions. Before reaching the latter situation they commonly descend again into the pelvis. The coils found in the pelvis belong usually to the lower ileum, and to the bowel between two points respectively six and twelve feet from the duodenum."

CAUSATION.—Violence coming from without, or arising within the canal, may be called the *exciting* cause, while the habits, occupation, idiosyncrasy, and surroundings of the patient are the *predisposing* causes. The nature of intestinal wounds usually indicates the cause, though a single form of violence may produce a wound of multiform characteristics. The direction and degree of the force, and the magnitude and character of the agent transmitting it, determine the extent, and largely also the number and variety, of the wounds inflicted. The direction of a wound of the intestines, and also its size, exert an important influence on the local physical phenomena.

Contused and Lacerated Wounds.—In contusions the intestinal walls are bruised, in lacerations they are torn. These forms are commonly due to external violence, and when thus caused both varieties of wounds may be well marked at or near the same situation. Usually a considerable degree of external violence, sufficient to involve the abdominal wall, is required to cause a laceration or a severe contusion of the intestines, owing to their mobility and flexibility, and also to their elusive nature dependent on their investing tissues. Despite this fact, however, cases of laceration and contusion occur from blows so slight or through agents of seemingly so innocent a character that no injury is done to the abdominal walls, and at first a wound of the intestines is not suspected. MacCormac has reported several such cases, and the writer has met with one. Usually the agents transmitting the force have a blunt outline. The passage of the wheel of a loaded vehicle over the abdomen offers a frequent illustration of the manner in which the violence is inflicted; also a blow from the clenched hand or the kick of a horse or a man, especially if the intestine be forced against the spinal column, or if the violence be received at a point where fæcal impaction exists. Partial distention of the bowel, according to Curtis, who made an analysis of 116 cases, diminishes the danger of rupture, while great distention of an isolated loop increases it, even when the loop is not in contact with bony parts. The intestines may be bruised and perhaps lacerated by imprudent manipulations for the reduction of a hernia, and the colon has been torn by the incautious introduction of the hand or an instrument into the sigmoid flexure. Contusions with or without lacerations have been caused by kneading the abdomen to overcome intestinal obstructions dependent on fæcal impaction, and rupture has occurred from the force exerted by circumscribed collections of gas generated in morbid obstructive conditions. The force of spent pieces of shell has caused laceration of the small intestine. In 113 of the cases analyzed by Curtis, the duodenum was injured in 6 instances, the

jejunum in 44, the ileum in 38, the colon in 4, and other portions of the intestine in 21. According to Morton and MacKenzie, in 345 cases of abdominal contusion the intestine was ruptured in 31 instances. Vulliet reports 171 cases of cœliotomy for lacerated and punctured wounds of the abdomen with intestinal involvement in 71. In 133 similar cases Adler noted intestinal injury in 32. In 144 like cases Lühe found that the intestine had escaped injury in 38, and there was no visceral lesion whatever in 24 instances.

Non-penetrating gunshot wounds of the intestine are essentially contused injuries of that structure. In cases of penetrating gunshot injury, the character of the intestinal wound assumes a different aspect. Still, even here one frequently meets with both contused and lacerated wounds, independent of those due to direct penetration, in places where, owing to the mobility of the intestine or perhaps because of a mere impingement upon it, the missile fails to cause direct penetration. It is proper to say, also, that the borders of a penetrating gunshot wound of the intestine often possess the characteristic features of ordinary lacerated and contused wounds, although, for obvious reasons, in a minor degree.

Penetrating gunshot wounds of the intestine are comparatively more frequent in civil than in military life, as in the latter the trunk is exposed as little as possible and the missiles fly high, while in the former the attack is often unexpected, and the recipient is therefore illy prepared to guard against it. Moreover, in civil encounters the range is shorter, hence the aim is better. It is interesting to note that the percentage of gunshot injuries of the abdomen reported as occurring during the late Civil War was astonishingly small (about 0.035), while that of head injuries was 0.15. The larger percentage of the latter is due to the greater exposure of this part of the body. No definite estimate can be made, prior to investigation, of the number, size, direction, or exact nature of the injuries of the intestine that may follow a penetrating gunshot wound of the abdomen.

SYMPTOMS.—Pain, tenderness, tympanites, and bloody stools, with or without the protrusion of the viscus and the escape of the intestinal contents, are common symptoms of intestinal wounds. They are greatly modified, however, with reference to their presence and their association with each other, by the nature of the wound itself.

Pain and Tenderness.—Pain is not a reliable symptom. Soon after the occurrence of an injury, there may be little, or indeed none, even when perforations are present. Commonly, however, pain and tenderness are among the first of the abdominal symptoms. Located primarily at the seat of the wound, the pain is dull or lancinating in quality, the former being more characteristic of contused wounds. As a rule it increases rapidly, becomes burning in character, and is accompanied by exquisite tenderness of the abdomen, retraction of the thighs, and obstinate constipation. It is increased by any muscular exertion, even the act of breathing. Sometimes there are griping pains with a desire to go to stool. Retention of urine may occur, due to the shock, to the peritonitis, or to the treatment employed.

Emphysema.—This sign is not associated very frequently with penetrating wounds of the abdomen, but when present is usually due to the escape of intestinal gases into the connective tissues situated between the intestine and the abdominal walls; hence it is associated especially with injuries of those portions of the intestinal tract that are not entirely surrounded by peritoneum. It may be limited to the immediate neighborhood of the injury, or may become general by spreading gradually into the surrounding tissue. It may also be due entirely or in part to a complicating wound of pulmonary tissue. Emphysema has been considered by some writers to be a certain sign of intestinal perforation, when associated with a suspected penetrating abdominal wound. Its diagnostic value is much lessened, however, by the fact that it has been frequently observed in connection with non-penetrating wounds of the abdominal wall, one such instance having fallen within the observation of the writer. If septic processes occur in the course of a penetrating wound of the abdomen, emphysema may result even though the intestine itself has not been injured. In such cases, however, the appearance of the emphysema is delayed. The important bearing of leucocytosis on peritoneal involvement in intestinal wounds, to be ascertained by a prompt blood count, should not be disregarded. Nor should we forget that a profound complicating sepsis may mislead by inhibiting leucocytosis.

DIAGNOSIS.—The diagnosis of contused and lacerated wounds can readily be made from wounds of all other forms, but to differentiate between these two is more difficult. There will be a history of abdominal injury received in some such way as already indicated. There may be external evidences of such injury, though in some instances there are none. If the intestinal wound is a *contused* one, there will be evidence of shock. Respiration may be modified by the pain attendant on the act of breathing. Vomiting is a frequent but not constant symptom. Pain is usually present in the beginning, not so acute as in lacerated wounds, but dull, deep-seated, and burning, denoting a beginning inflammation. These symptoms may subside in a few days, or they may be quickly followed by a sudden increase in the pain and more urgent manifestations of peritonitis, or by collapse. These unfavorable symptoms may be caused by the rapid increase of a localized inflammation, by a sudden hemorrhage from a previously contused vessel, or more commonly by a sudden extravasation following sloughing of some portion of the intestinal wall. The constitutional symptoms keep pace with the local. The temperature rises, the pulse becomes more frequent and harder, and the patient soon shows evidence of collapse.

The degree of tympanitic distention of the abdomen is usually proportionate to the extent and intensity of the inflammation. The tympanites may be due to the presence of air in the peritoneal cavity or in the intestine. In the former condition it comes from a wound in the gut, and in cases of contused wounds it will therefore occur at or soon after the exacerbation of symptoms, while in lacerated wounds it follows quickly the intestinal injury. Tympanites due to intestinal distention comes more slowly and is less in degree. *In lacerated wounds*, fæcal extravasation occurs as a rule. It was present in 107 out of 113 cases (Curtis). The symptoms for this reason appear earlier than in contused wounds and are more severe. In both varieties there may be vomiting of blood, particularly if the duodenum or jejunum is injured. Vulliet noted hæmatemesis in but one of 114 cases of lacerated and punctured wounds of the intestine, although the stomach was injured in 15 of these cases. The same writer found this manifestation in 10 of 85 cases of projectile wounds. Blood may also be passed at stool, and if it is small in quantity and clotted, it indicates injury to the ileum. If the blood traverses a considerable portion of the intestine, it will be darkened in color and increased in consistence by the action of the intestinal fluids. The possibility of coincident diseases of the intestines causing hemorrhage must not be forgotten.

Nor must it be forgotten that a patient may have received either a contused or a lacerated wound of the intestines, and yet present no symptoms for a few hours. MacCormac has reported one such case, and two others in which vomiting was the only symptom, yet in all three there was rupture of the intestine and death occurred within forty-eight hours.

Hydrogen gas is recommended by Senn as a means of determining whether or not, in a case of penetrating abdominal wound, perforations of the intestine coexist. Senn has demonstrated that under slight but steady pressure, the patient being relaxed by an anæsthetic, the gas may be forced from the anus past the ileo-cæcal valve to the mouth. If perforations exist the gas escapes into the peritoneal cavity, its presence being denoted by general tympanites, loss of liver-dulness, etc., or it will appear at the abdominal wound, where it may be ignited. If

the distention follows the line of the colon, and, after passing the valve, is confined to the umbilical and hypogastric regions, it indicates that the intestine is intact. The gas in passing the valve causes a blowing or gurgling sound which may easily be heard with a stethoscope. The method of using it is as follows: Hydrogen gas, generated in the ordinary manner (care being taken to have it pure), is collected in a rubber bag holding about four gallons. This bag is connected with a rectal tip by means of a rubber tubing and stopcock. The rubber bag being filled, the rectal tip is inserted and the margin of the anus pressed against it to prevent the return of the gas; the bag is now subjected to gentle pressure, the valve yielding to a force varying from one-half to two pounds. If the external wound points to the possibility of stomach injury, then insufflation should be practised through a stomach tube. The disadvantages of the method are that it prolongs the operation, sometimes makes the returning of the bowels a very difficult matter, and occasionally, when perforations exist, it fails to reveal them—items which, according to the majority of observers, outweigh its advantages. In addition to this, there exists the danger of forcing a portion of the intestinal contents into the abdominal cavity, particularly if such contents are fluid and located near or at the point of perforation.

TREATMENT.—*Local Treatment of Hemorrhage.*—Hemorrhage through the abdominal wound may either arise from the wound itself or have an intra-abdominal source. In either case the indication is to secure the bleeding vessel. This can be easily done if it is situated in the abdominal wall, although it may be necessary to enlarge the opening for that purpose. Bleeding from within the cavity is considered in the great majority of cases a positive indication for laparotomy. Its treatment in connection with laparotomy will be referred to in the section on gunshot wounds. If, in a given case, for any reason laparotomy may not be performed, the treatment should be palliative. The patient is kept quiet, and cold applications are made to the abdomen. The external wound should remain unobstructed, so as to permit the free escape of blood that might otherwise collect in the abdominal cavity. A dressing of moist antiseptic gauze will serve the double purpose of protecting the wound and acting as a drain. In these admittedly hopeless cases, it is probable that pressure on the abdominal aorta, combined with saline transfusion, will prolong the patient's life. Should the hemorrhage thus be controlled, laparotomy during continuance of the pressure on the aorta may yet offer an additional means of preserving life. Compression of the abdomen by means of a tightly drawn body bandage may, in some instances, prove serviceable in the control of bleeding.

Lacerated and Contused Wounds.—A lacerated or contused wound of the intestine may or may not call for abdominal section. There is less danger of fæcal extravasation in such a wound than in one associated with abdominal penetration, as the penetrating agent may carry infection from the intestinal wound into the peritoneal cavity. If the symptoms are mild and rupture seems improbable, the expectant plan should be adopted. At all events, the performance of laparotomy should be deemed unwise in these cases after sufficient time has elapsed to permit the formation of adhesions contiguous to the injured portion. Severe hemorrhage or serious visceral lesion demands prompt operative interference. Laparotomy to be serviceable must be done early, and not deferred until peritonitis sets in. In a collection of eleven cases operated on after a few hours had elapsed, and as peritonitis was beginning, all terminated fatally. Shock, usually great in these cases, is much increased by a long operation. For this reason, when resection of the gut is necessary, many advocate the formation of an artificial anus. The choice between this and enterorrhaphy will depend in a measure on the experience and preparation of the operator. A wound located so high up in the intestine that rapid impoverishment of the patient would follow the formation of an artificial anus should be treated by enterorrhaphy, even though the patient might thereby be exposed to greater immediate danger.

Punctured and Incised Wounds.—Incised wounds of the intestines are more dangerous than punctured ones, because of the greater liability to hemorrhage and extravasation. Their general treatment is similar to that of other varieties. In performing laparotomy the incision is usually made in the line of the wound rather than in the median line, because it affords the most direct route to what is usually a limited injury.

Gunshot Wounds.—In opening the peritoneal cavity, in the case of a gunshot wound, the incision should be made in the median line, especially when it appears that an opening made at the seat of injury will not offer an adequate opportunity for a proper inspection and treatment of the injured parts. The probable direction taken by the missile should be considered in all such instances. It has been advised, and wisely, that, when the intra-abdominal wound is probably limited to the more fixed portions of the intestinal tract or to other abdominal viscera, in the absence of symptoms of hemorrhage, the incision be made in the line of the abdominal wound. After the peritoneal cavity has been opened, in the place of forceps, which bruise the tissues, long sutures of silk or catgut should be passed through the peritoneal borders in order to prevent retraction, being held by an assistant or otherwise properly anchored.

The agents employed for repair of the intestine are the usual materials for ligatures, sutures, etc. Carbolized iron-dyed silk may be employed for both purposes, or aseptic catgut of small sizes may be used exclusively for ligatures, although some prefer to rely solely on silk. The needles required for sewing peritoneal and intestinal surfaces will depend on the preference of the operator, some using curved needles of small size and without sharp edges, others ordinary straight, slender sewing needles. The latter are particularly serviceable in introducing the Lembert suture. In addition, there are required thumb and mouse-tooth forceps to raise the borders of the wound, artery and needle forceps for obvious purposes, large catch-forceps with horseshoe-shaped blades to close the openings of a similar shape at the side of the intestine, two or three long-bladed catch-forceps with the blades protected by rubber tubing to compress the intestine transversely, holding back its contents above and below the wound. (Several instruments have been devised for this, but the fingers of an assistant are best and safest.) Curved and straight scissors, aneurism needle, grooved director, scalpels, and other common surgical instruments also, are necessary.

After the abdominal cavity has been opened, the blood and fæcal matter under observation should be removed with small aseptic sponges or pads as soon as seen. This should be done very carefully, when possible by gentle pressure rather than by wiping movements, as the latter provoke the further spread of the infecting agents, and also impair the integrity of the serous surface. In either case the sponge or pad should be changed with each effort at removal. The bleeding points immediately under notice should be tied. It is important to remember that penetrating intestinal wounds should be closed as soon as found, otherwise they may escape from notice, and thereby furnish an additional risk of infecting the peritoneal cavity. The introduction of the finger or of an instrument into the intestine through the wound, to detect the presence in the gut of a foreign body, should not be practised, since little or no good can follow, and exceeding harm may arise through infection at the point of entrance or through manipulative extrusion of the intestinal contents at a possible wound in another part of the gut. This same precaution may be wisely heeded in wounds of the stomach.

The repair of the intestine should be accomplished by one of two methods: (1) by direct closure of the openings; (2) by excision of a portion of the intestine and the union of the divided extremities, which union may be accomplished by either circular enterorrhaphy or lateral anastomosis (page 178). The former method may be adopted

when the closure of the wound will not diminish the intestinal calibre more than one-third; either of the latter methods, when the gut is extensively injured. In certain wounds when direct closure will narrow the calibre more than one-third, additional room may be gained by closing the wound transversely. To do this it may be necessary to increase the size of the wound by making longitudinal incisions of suitable and equal lengths at either end of it. The intestinal wall is then grasped at corresponding points on opposite sides and drawn upon; the longitudinal wound is thus converted into a transverse one, and in this position its borders are united. By this means a certain amount of "elbowing" is produced. While, as a rule, it is unwise to trim the borders of intestinal wounds, yet care should be taken to examine the border of a wound contiguous to an important vessel, to ascertain if the integrity of the vessel has been endangered; otherwise the closure without this precaution may be followed by secondary hemorrhage.

The wound may then be closed by either the Lembert or continuous sutures. A double row of the Lembert or continuous suture may be made, or a single row of each, or the Czerny-Lembert. Of the continuous varieties, the right-angle continuous suture of Cushing is advisable. (See article on *Sutures*.)

The sutures, to be reliable, should go down to and embrace a thread or two of the submucosa, and not be more than three lines apart. Sutures limited to the serous coat alone are insecure and dangerous, and those entering the lumen, although less seriously considered than formerly, are yet to be regarded with wise distrust. The best material for suturing the intestine is the loose-textured carbolized iron-dyed silk.

If the mesenteric border only of the intestine is wounded, the injured portion of the gut should be excised, because gangrene is liable to follow from injury to the vessels of the part.

When the intestine is completely severed, either by the original injury or by the knife of the surgeon, the difficulty of adjusting the cut borders is much increased. The portion to be repaired must be drawn well out of the abdominal wound and carefully isolated by sponges and pads that completely prevent blood, fæces, etc., from entering the abdominal cavity. The uppermost extremity of the divided intestine will be known by the greater amount of fæcal matter seen at its open end. The intestinal contents must be pushed aside for some distance from the part to be operated on, and the bowel occluded above and below. This occlusion may be effected by using the clamps already referred to, or by making a hole in the mesentery and ligating the intestine with either a cord of iodoform gauze or a flat india-rubber band. The fingers of an assistant serve better than anything else. The clamps may cause sloughing if carelessly or continuously applied. The excision is made with sharp, straight-bladed scissors usually at a right angle to the long axis of the intestine. The length of the portion removed will depend on the extent of the injury; it should always be sufficient to include the seat of injury, even though it may be six or eight inches in extent, and when multiple perforations exist near each other, it is advisable to include them all in one resection, even if the portion of intestine removed must be three or more feet in length.

The vascular supply of the intestine at the seat of injury should be carefully examined, and all that portion of gut excised that has an impaired supply of blood, else gangrene of the bowel may ensue. In fact, it is a wise precaution in excision always to divide the gut at a point which will afford the best vascular supply to the extremities to be united—that is, close to the entrance of a mesenteric vessel into the uninjured portion. The mesentery corresponding to the portion of gut removed can be cut away in the form of an isosceles triangle, the base of which shall correspond to its intestinal attachment, or it may be ligated *en masse* or in sections at its point of attachment, and allowed to remain free in the abdominal cavity. The latter plan is unsafe, since, owing to the feeble vitality of its tissue, gangrene of the distal extremities of the mesenteric stumps frequently ensues. Parkes advised that the entire mass be included in one ligature drawn tight enough to check the bleeding, and that then, after the intestine has been united, the stump be stitched to the seat of operation, thereby forming again as nearly as possible a continuous mesentery. Another method is to make two incisions, one on each side of the mesenteric attachment and at a distance of about half an inch from it, through the wall of the intestine in its long axis corresponding in length to the portion of the intestine to be removed. The mucous lining of this mesenteric strip should then be torn away and its peritoneal borders united by a continuous suture of fine catgut. After the excision is completed and the ends of the intestine have been united, the mesenteric strip will present a looped appearance due to the approximation of the intestinal extremities. The opening of this loop should be united by sutures, and the opposed surfaces of mesentery should also be transfixed, to prevent the formation of a pocket there. When the ligature *en masse* is employed, it is not considered safe to use catgut.

As soon as all hemorrhage has been checked, the divided ends of the intestine are approximated by an assistant and some form of suture is introduced. The suturing is begun at the mesenteric border, care being taken to close tightly the triangular space at this point caused by the reflexion of the peritoneum from the walls of the intestine. After this, the protruding mucous membrane is pushed into the intestine and a suture is introduced at each of the three remaining aspects of the bowel, and then the intervening spaces are properly sewed. This is a better plan than to begin to sew at any given point and go directly around. If a Lembert is used, at least three or four lines of peritoneum should be included in the grasp of the suture at each extremity of the intestine. A suture should be drawn only sufficiently tight to bring the severed borders in close apposition, for if drawn too tightly the tissue grasped by it will slough. If a single row of sutures is to be made, they should be placed about 5 mm. apart. If a double row is to be employed, those of the first can be deposited within 6 or 7 mm. of each other, and those of the second at intervals between the former. After the bowel is united, it is well to return to the mesenteric border. This is the weakest portion of the wound. It should be covered by stitching the two peritoneal layers of the mesentery over it, or by an omental graft.

Omental Grafting.—In certain experiments on dogs, Senn fixed a flap of omentum over the seam of an enterorrhaphy, the free or distal end being attached over the seam, the proximal remaining continuous with the omentum. These soon grew in place and thus reinforced the bowel. To avoid the danger of strangulation occurring through the loop thus formed, isolated grafts were employed and fixed round the suture. In every instance they retained their vitality. In performing the operation, the intestinal peritoneum is lightly scarified before the flap is put in position, and in a few hours it is adherent. Intestinal end-to-end or lateral approximation, by means of Senn's plates, Murphy's button, and various analogous procedures, and also by the different methods of suture, is elsewhere fully described.

Cleansing the Peritoneal Cavity and Closing the Abdominal Wound.—All the bleeding points must be closed by ligature if possible, if not, then by cautery. It must not be forgotten that the tendency of intra-abdominal vessels to bleed when not exposed to the air is very great; therefore a simple oozing before the closure of the abdominal walls is likely to become a formidable hemorrhage afterward; and even though the secondary oozing be not sufficient to imperil life by loss of blood, it is liable to do so by causing inflammatory or septic processes. The blood and other fluids, fæcal matters, and all other foreign agents must be removed from the abdominal cavity, and the surface of the peritoneum with its cul-de-sac thoroughly mopped with soft aseptic sponges soaked in hot decinormal saline solution. Too great care cannot be taken in sponging away the foreign matters, and, as al-

ready stated, the same portion of the sponge should be applied to a serous surface but once, since to apply it repeatedly causes quite as surely the dissemination as the removal of the irritating agents, and the friction impairs and destroys the epithelial surface.

Malcolm, of London, advises flushing out the abdominal cavity for the purpose of adjusting naturally the intestinal folds. The saline solution at the temperature of 110° F. is poured into the cavity from a pitcher until the intestinal folds float up, subsiding later into their normal positions. The fluid is poured in until it returns clear. Flushing with hot fluid cleanses the peritoneal cavity, and, besides, acts as a stimulant. The leaving in the peritoneal cavity of a quart or so of hot saline solution, to dilute infecting agents and facilitate their removal, has the sanction of common practice, supported by favorable results. Whether the normal upward absorption flow should be facilitated by raising the foot of the bed (Kelly) or hindered by lowering it (Fowler) in instances of peritoneal infection, requires further study before a final conclusion can be reached. In this connection it is proper to recall that G. Wegner determined that the hourly absorption capacity of the peritoneum for fluids equalled from three to eight per cent. of the weight of the animal subjected to the experiment.

The abdominal wound should be closed by three rows of sutures. One should be continuous of fine, strong silk, perhaps chromatized catgut, and should include the serous and subserous tissues and the transversalis fascia. The practice of making a deep row of interrupted sutures widely separated, or of including the whole thickness of the abdominal wall in one such row, is to be condemned. The pockets or dimples of peritoneum which are thereby formed between the stitches invite the occurrence of hernia, and often beget dead spaces. The second row may be of silk or catgut, interrupted or continuous, including the aponeurotic and muscular tissues. The third row should be of interrupted silkworm gut or fine silver wire, and should effect the closure of the integument and subcutaneous part of the wound. Retaining sutures introduced outside of the preceding may be employed if undue tension be present or anticipated. If necessary, the wound may be drained. And last of all, an antiseptic or aseptic dressing is to be applied. The patient should be quieted by small doses of an opiate; the diet should be light at first and of a nature to leave little or no residue. The bowel contents ought to be maintained in a soluble state by means of saline medication when septic intraperitoneal processes are present. The bladder should be evacuated with a catheter.

Prognosis.—Ruptured or lacerated wounds have thus far proved exceedingly fatal. Of five cases reported during the late Civil War all were fatal. Curtis reports eight cases which were operated on, and death occurred in all. Since then several others, in which laparotomy was performed, have been reported, only one of which, that of Crofts, was successful.

The prognosis in cases of gunshot wounds of the intestines, when treated by laparotomy, has of late years vastly improved. In 1887, Morton published a series of 22 cases with a little less than 23 per cent. of recoveries. About the same time MacCormac collected 30 cases in which laparotomy had been performed (Morton's were included), and gave the recoveries at a little over 23 per cent. Since then a collection of 35 cases shows 18 recoveries, or a little over 51 per cent.

In cases of laparotomy for contusions, Gachon (1895) found a mortality of 20 per cent. in early operations, while if the intervention was after the twentieth hour the mortality was 73 per cent. Petry (1896) found that after 42 first-day operations there were 33 per cent. recoveries; and that in 24 cases operated on after the first day there were 25 per cent. recoveries.

Adler (1892) found that in 154 cases of projectile wounds of the abdomen, in only 11 was serious visceral injury absent. Lühe (1890 and 1892) found that in 191 cases, 21 escaped intestinal injury and 6 escaped all visceral injury. Duroselle (1894) found that but 5 escaped visceral injury in 155 cases. Vulliet (1897) found that 12 escaped out of 83.

Vulliet mentions a series of 27 cases of lacerated and punctured wounds collected since 1890 which were treated expectantly. The percentage of recoveries was 57. In a series of 43 cases of projectile wounds treated expectantly, the percentage of deaths was 46.5. The same author speaks of the expectancy mortality of lacerated wounds as 37 per cent.; of projectile wounds as 50 per cent., referring probably to all cases since 1890. Reclus and Noguet claim that by the let-alone plan in 88 cases the mortality was but 25 per cent (this report appears to refer to wounds irrespective of causes).

In Coley's second series (1891) of laparotomies for penetrating wounds of the abdomen, amounting to 165 cases, the mortality was 67.2 per cent. Reclus and Noguet found the same mortality rate, 78 per cent. in 73 cases. Vulliet states that in 40 cases of laparotomy for projectile wounds performed during the first twelve hours, the mortality was 44 per cent.; after the first twelve hours, 50 per cent. Adler's figures correspond closely to those of Vulliet's.

Dörfler, the most recent writer (1897), states that the mortality from laparotomy in cases of projectile wounds performed in the first five hours is 50 per cent.; before twelve hours, 55 per cent.; after twelve hours, 70.5 per cent.

Laparotomy for instrumental wounds in the first five hours has the low mortality of 16 per cent. Fenner reports the following outcome of laparotomy in Charity Hospital, New Orleans, from January, 1892, to January, 1901: Gunshot wound of the abdomen 113 cases with 78 deaths; stab wounds of the abdomen 39 cases with 9 deaths.

Of stab wounds which were operated on, Morton reported 19 cases with 63 per cent. recoveries; MacCormac 18 cases with over 55 per cent. of recoveries. A collection of 19 cases made since then gives over 79 per cent. of recoveries.

Joseph D. Bryant.

INTRAVENOUS INJECTIONS.—This method of introducing substances into the body may be said to have a very limited field of usefulness in practical medicine, though it is the common method with animals in the laboratory. The mouth and rectum will always be the readiest ports of entry to the body. When these cannot be used, or when rapidity and certainty of action are needed, the hypodermic needle will usually meet the needs of the case. Rarely will the advantages of the intravenous route overweigh its dangers and difficulties.

The advantages of the intravenous method are: 1. Greater rapidity of absorption. This is certainly a just claim and constitutes the chief indication for the use of the method. 2. Greater certainty of absorption. Ordinarily the absorption of substances introduced under the skin may be reckoned as certain, but sometimes when a patient is *in extremis*, as in severe surgical shock, fluids placed under the skin are taken up but very slowly. 3. It is painless. Some irritating substances, such as mercurials, cause considerable pain when introduced hypodermically, but when injected into a vein they are so rapidly swept away into the general circulation that no local pain can occur. 4. Abscesses are less apt to occur for the same reason. One should not on this account, however, be less careful in regard to asepsis.

The disadvantages as compared to the subcutaneous method are: 1. Greater danger. This arises rather from failure to observe proper precautions than from any faults inherent in the method. When carefully and judiciously used the method is safe enough to be employed in the emergencies in which it is needed. The chief danger is probably from embolism. The substances introduced cause the formation of a clot which is carried to the right heart and thence to the lungs. If only agents known to be harmless when thus used are employed, if they are sufficiently diluted and are introduced slowly, there is little danger from this source. Thrombosis with ulceration has resulted from injections into a vessel in the foot

of a patient with varicose veins. The introduction of air is a danger that may be avoided by care. 2. The action of a drug when put directly into the blood may be different, qualitatively and quantitatively, from its action when it is given by the mouth or by the skin, because it reaches the blood and is carried to the heart and other organs in such concentrated form—an objection which may be partly overcome by using dilute solutions and giving them slowly. 3. The more difficult technique is often spoken of as the greatest objection. It is sometimes hard, especially in women, to put a needle through the skin directly into a vein. Even after the vein is exposed it may be an exasperatingly delicate operation to get a cannula into it.

The amount of care and skill needed to avoid the dangers and difficulties, then, is so great as to forbid the use of intravenous injections as a routine measure. The procedure is to be reserved for those cases in which other methods have failed, or in which an emergency demands great haste.

The following are some of the special instances in which intravenous injections have been used:

In syphilis the intravenous use of mercurials has been especially advocated by Bacccelli. The solution used is as follows:

Corrosive sublimate	1
Sodium chloride........................	3
Distilled water..........................	1,000

One cubic centimetre of this (1 mgm. of mercury) is the usual dose, but in urgent cases it may be increased. The cyanide has also been used. This procedure may be of value in those few cases in which mercury does not appear to produce its usual good effect when given in the ordinary ways or in which rapid advance of the disease makes it essential to get the patient mercurialized at the earliest possible moment. Besides the dangers already mentioned, the intravenous use of mercury has been followed by severe ptyalism even after small doses. For ordinary cases the method has no advantages over the simpler ones in common use.

Baccelli has also urged the intravenous administration of quinine in pernicious malaria. The following solution is used, acid solutions not being permissible:

Quinine hydrochlorate................	gr. xv.
Sodium chloride	gr. xij.
Distilled water........................	ʒ iiss.

This is to be boiled and filtered. Symptoms of cinchonism, ephemeral in duration, may appear soon after the use of gr. xv. of quinine in this way. As in the case of mercury this method is to be reserved for the treatment of pernicious cases when quinine given in the ordinary ways has proved of no avail, or when great haste is demanded.

For the purpose of introducing into the circulation large quantities of artificial serum in surgical shock or hemorrhage or for "washing the blood" in uræmia, septicæmia or other toxæmic states, and in collapse from cholera—for these purposes intravenous injections are of the greatest value. In such cases only will the average practitioner ever be called upon to use them. In general we may say that the indications for the intravenous injection of salt solution are the same as for hypodermoclysis, and the reader is referred to the article with that title. And the hypodermic method, by reason of superior convenience and safety, will almost always be chosen. But in certain cases of extreme shock, absorption from the subcutaneous tissue is slow and uncertain. Thus Jones reports two cases in which, owing to failure of absorption from the skin, hypodermoclysis was ineffectual; on using the veins, however, both patients speedily improved. Again, when hemorrhage has been profuse and every moment is of value, the intravenous route is the best. Ringer's solution (see *Hypodermoclysis*) or 0.6-per-cent. salt solution may be employed. Milk or distilled water—both of which have been employed with fatal results—are mentioned only to be condemned.

Intravenous injections have been recently used in diabetes mellitus, especially in coma, and in accordance with the theory that the coma is due to an acid intoxication, large quantities of sodium bicarbonate are given in this manner. Three per cent. of sodium bicarbonate is added to decinormal salt solution and upward of a quart given. A discussion of the value of this procedure would be out of place here. It need only be said that the improvement is often striking, but if coma is well developed it is usually temporary. The intravenous route is the one usually selected in urgent cases—*i.e.*, in cases in which time is of importance.

Gelatin solutions have been used intravenously in aneurism, internal hemorrhages, hæmophilia, and other hemorrhagic conditions. The subcutaneous route is the one ordinarily chosen, the mouth and rectum being used at the same time. The intravenous route is hardly justifiable, and indeed the whole matter is still *sub judice*.

Intravenous feeding has been tried but is too dangerous to be of practical value.

Technique.—This varies with the substance to be introduced or, more properly, with the amount of fluid used. Small quantities, as in the case of mercury or of quinine, are best inserted directly into the vein. The arm is constricted by a bandage above the elbow so as to shut off the return of blood and distend the veins. The largest vein near the bend of the elbow is selected, and the field is rendered sterile by scrubbing with soap and then with corrosive sublimate solution. The sterilized needle is then introduced directly into the vein through the skin. It must point upward in the direction of the circulation. The bandage is then removed and the injection is slowly made. If the needle has not entered the vessel a small tumor will be formed and the attempt must be repeated. The solution should always be warm when introduced. Any syringe may be used which has a capacity of several drachms and which may be sterilized by boiling. The ordinary antitoxin syringe, made wholly of glass and packed with string, is as good as any. The only difficulty is in getting the needle into the vein. This is much lessened if care be taken to use a new and very sharp needle. The writer has easily inserted a needle into one of the comparatively small veins of the wrist. The vein is not injured and many injections may be made at the same point without producing any appreciable change in the walls of the vessel.

For the introduction of large quantities of fluid it is probably better to insert a cannula. After applying a bandage and rendering the field of operation sterile, as before, the vein is exposed by an incision and a double ligature is passed. The lower ligature is tied and the vein is partly opened by snipping with scissors. Into the opening thus made a glass cannula is inserted, or if this be not at hand a dulled hollow needle. The other ligature is now tightened about the cannula and the fluid is allowed to flow in from a height of one or two feet. Before starting the flow every precaution must be taken to see that the fluid contains no air. The injection is to be made slowly, at least fifteen minutes being taken for the introduction of a quart. The best temperature is about 110° F. After the operation is over the cannula is removed and the incision is closed and dressed. Every precaution should be taken to have the fluid and its container, all instruments and tubes, and the hands of the operator sterile. A glass irrigating apparatus with rubber tubing may be used, or in an emergency a rubber fountain syringe, sterilized by boiling. But the best apparatus consists of a large flask with a rubber stopper arranged like a wash bottle. Through two holes in the stopper glass tubes are passed. One, for the purpose of admitting air when the flask is inverted, leads to the bottom, and the other to which the rubber tube is attached leads just through the stopper. The whole apparatus filled with fluid may be sterilized in the steam sterilizer, or if an ordinary chemical flask is used it may be boiled over a tripod.

Ralph C. Larrabee.

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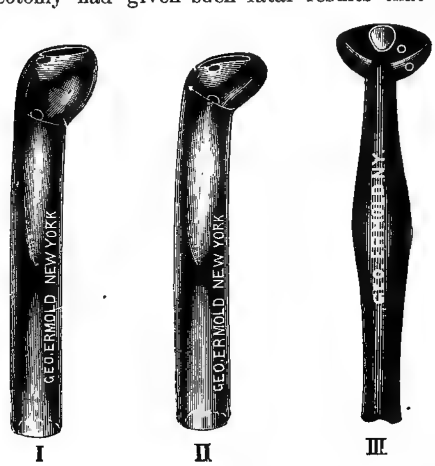
INTUBATION.—In 1856 Bouchut suggested and actually practised a crude method of intubation, which, however, the ridicule of his confrères soon forced him to abandon. Before this time, catheterization of the larynx had been practised to a certain extent for the temporary relief of urgent symptoms of stenosis, but with little success. In 1880 Dr. Joseph O'Dwyer, of New York, with no previous knowledge of the experiments of Bouchut, began to study the subject of intubation. This work extended over a period of three years and was performed at the New York Foundling Hospital, where the operation of tracheotomy had given such fatal results that it had



I II III

FIG. 2940.—Intubation Tubes. No. I., Granulation tube; No. II., lateral view of ordinary tube; No. III., anterior view of the same.

long since been abandoned. After many failures and a few partial successes, Dr. O'Dwyer gave to the world the perfected instruments as they are made to-day.

Intubation Instruments.—The tubes are made of hard rubber (the older metal tubes were found to promote the deposit of lime salts about the lumen and caused damage to the larynx if worn for more than a few days), in seven or more sizes suited to the various ages of childhood. A

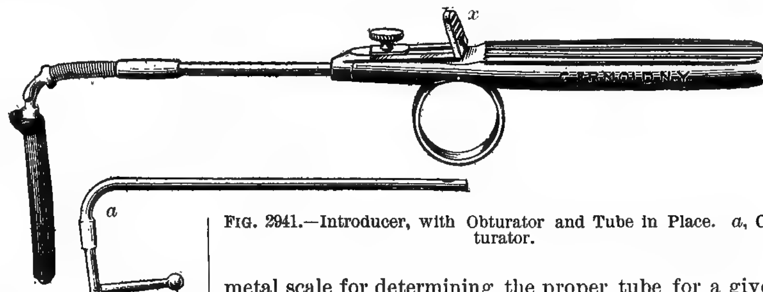


FIG. 2941.—Introducer, with Obturator and Tube in Place. *a*, Obturator.

metal scale for determining the proper tube for a given age accompanies each set of instruments. The tubes (Fig. 2940, Nos. II. and III.) are long enough to reach nearly to the bifurcation of the trachea, thus lessening the chance of obstruction by loose membrane. The retaining swell is sufficiently full to keep the tube in place and yet small enough to allow of ready expulsion when the lumen is blocked. The neck is narrow and adapted to the grip of the vocal cords.

Ulcerations were found to be caused by the earlier tubes at three points: 1. In the cricoid division of the larynx (the narrowest part); this is obviated by using the smallest possible tube for a given age. 2. At the base of the epiglottis; this is avoided in the modern tubes by giving the head a backward sweep and leaving a good deal of material at its anterior part, thus distributing the

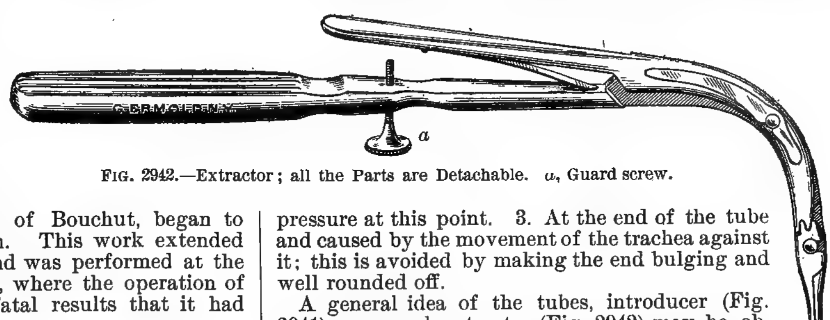


FIG. 2942.—Extractor; all the Parts are Detachable. *a*, Guard screw.

pressure at this point. 3. At the end of the tube and caused by the movement of the trachea against it; this is avoided by making the end bulging and well rounded off.

A general idea of the tubes, introducer (Fig. 2941), gag, and extractor (Fig. 2942) may be obtained from the accompanying illustrations. The obturator (Fig. 2941, *a*), one for each tube, fits into the introducer and is released from the tube by the thumb of the operator pushing forward the button at *x*. The mouth

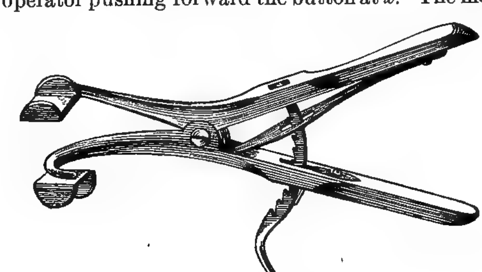


FIG. 2943.—Mouth Gag.

gag (Fig. 2943) is a powerful instrument and need not be used in young infants as it has the undesirable property of lacerating toothless gums.

In addition to the regular tubes there are tubes especially adapted to getting rid of loose pseudo-membrane. These are hollow cylinders of different sizes and of large calibre (Fig. 2944), short enough not to push down the membrane and long enough to reach below the cricoid

constriction. They have no retaining swell and it is therefore necessary to use the largest size possible, wedging it into the larynx. On no account should these tubes

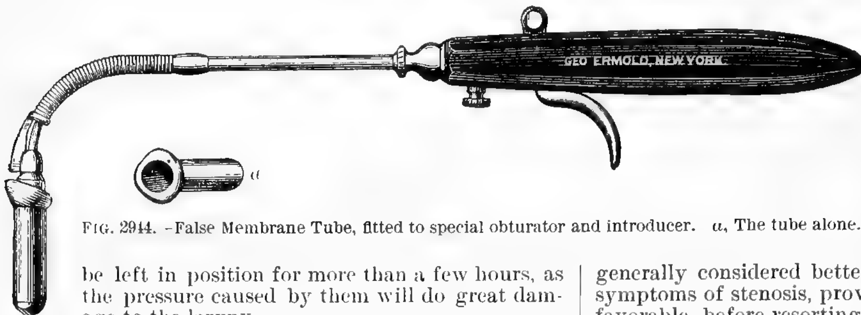


FIG. 2944.—False Membrane Tube, fitted to special obturator and introducer. *a*, The tube alone.

be left in position for more than a few hours, as the pressure caused by them will do great damage to the larynx.

Granulation tubes (Fig. 2940, No. I.) are constructed for cases in which previous intubation has caused the formation of granulation tissue about the larynx. They differ from the ordinary tubes in having a large built-up head, which rides above the granulations and by pressure tends to hasten their absorption.

With the exception of the short tube of Bayeux, which possesses the sole advantage of being better adapted to the operation of enucleation or removal by pressure through the trachea, it is unnecessary to mention here any of the so-called modifications of O'Dwyer's instruments, many of which have been discarded as useless and all are totally unnecessary. The O'Dwyer instruments as made by a reliable manufacturer, meet all the requirements for which they were intended.

The vast majority of cases requiring intubation are due to laryngeal diphtheria. Other conditions rarely requiring the operation are pseudo-diphtheria (streptococcus) of the larynx, catarrhal laryngitis, and laryngismus stridulus.

When to Intubate.—With the use of antitoxin it is generally considered better practice to wait for marked symptoms of stenosis, provided the patient's condition is favorable, before resorting to operation, in the hope that the serum, which is to be given in large doses at the first suspicion of laryngeal diphtheria, may do away with the necessity for operative interference.

The symptoms calling for operation are progressive dyspnœa, labored breathing and cyanosis, retraction of the tissues about the epigastrium and clavicles, diminished respiratory murmur over the lung bases, physical depression, and a failing pulse.

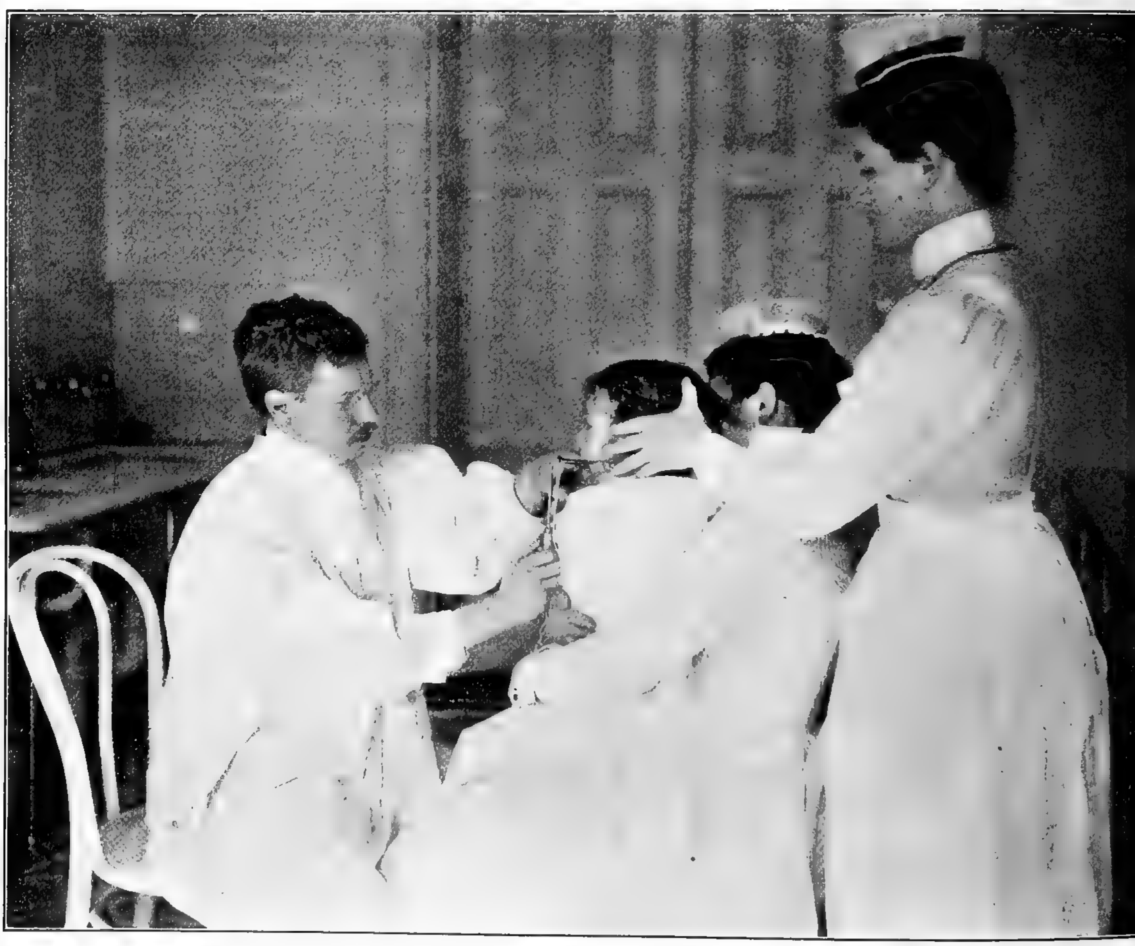


FIG. 2945.—Intubation. Correct position of operator, patient, and assistants. First position of the tube.

Technique of the Operation.—Intubation may be performed with the patient in either the upright or the dorsal position, the former being generally preferred. In either

case the patient is wrapped from the neck downward in a sheet or light blanket which includes the shoulders, arms, and hands, care being taken to avoid a bulky roll in front of the neck, which interferes with the handle of the introducer at the beginning of the operation. The nurse sits upright in a straight-back chair, holding the child firmly against her left breast and shoulder, by crossing the arms in front of the child's body outside of

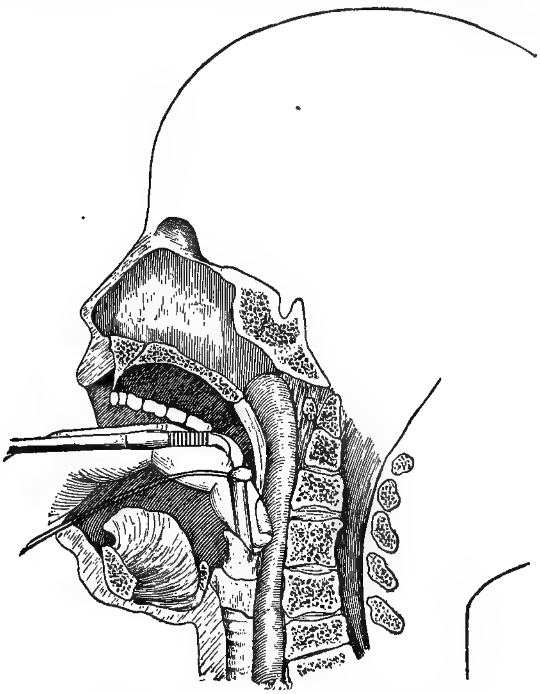


FIG. 2946.—The Tube Just Engaged in the Larynx.

the wrapper. The legs of the patient are gripped firmly between the knees of the nurse, the assisting physician standing behind the chair grasps the patient's head between his hands and holds it perfectly straight in a position as though the child *hung from the top of its head.*

The operator, seated or standing directly in front of the patient, inserts the mouth gag well back between the jaws of the left side, opens the mouth widely and gives the handle of the instrument to the assistant who includes it between his left hand and the patient's cheek. A tube of the proper size having been selected and its eye threaded, preferably with braided silk, care is taken to see that it slips easily from the obturator, which has been previously fitted to the introducer. The operator then inserts his left index finger into the patient's mouth, hooks back the epiglottis, crowds the finger as much as possible to the left and passes the tube, in the middle line along it, and just under its edge until the tip of the tube engages in the glottis (Fig. 2946). The handle of the introducer is at first depressed and nearly parallel to the patient's body; as the tube approaches the larynx, the handle is gradually raised until the tube actually engages in the chink of the glottis, when the elevation of the introducer should be abrupt so that the tube points directly down the trachea. By gentle pressure it is passed downward until the introducer lies crowded against the tongue (Fig. 2947). The left forefinger is then taken from the epiglottis and placed on the head of the tube, which with a gentle thrust it pushes home at the same time that the obturator is released and withdrawn from the mouth (Fig. 2948). The left forefinger and gag are then removed.

The characteristic respiratory sound, cough, and expectoration, together with immediate relief from the dyspnœa, indicate that the tube is in position. The string is left in for fifteen or twenty minutes to make certain that the calibre of the tube is free from obstruction by loose membrane or thick mucus, after which one end of it is severed close to the angle of the mouth, and while the left forefinger holds the tube in place it is quickly pulled out. It is not necessary, as a rule, to insert the mouth gag for this purpose. In infants, the string may be left in place during the entire period of intubation. In such a case it is to be hooked up behind the ear and fastened to the cheek by a bit of adhesive plaster. In older children it causes annoyance, may be pulled on with consequent removal of the tube, and is very apt to be severed by the back teeth. The points to be emphasized in the operation are, in brief: Hold the introducer lightly between the thumb and fingers, using no force. Keep the introducer as nearly as possible in the median line. Be sure that the position of the child is correct and that it is held absolutely immobile. See that everything is in readiness before beginning the operation. If not successful in introducing the tube at the first trial, begin all over, making, if necessary, repeated short attempts rather than a single prolonged one.

Dr. Bryant of the Willard Parker Hospital prefers to intubate with the patient in the dorsal position. Here the same rules apply as those given for the upright position. The dorsal position has the advantage of making the operation possible without the aid of assistants. For this purpose the child is wrapped up as above described and placed on a table. The operator's knee is pressed between the patient's thighs, the gag is introduced and allowed to hang in place, and the tube is passed in the usual way. It need not be said that this method of operation necessitates great skill on the operator's part, and should never be attempted unless assistance is absolutely unattainable.

EXTUBATION.—In the removal of the tube, the patient's position should be the same as that adopted for its intro-

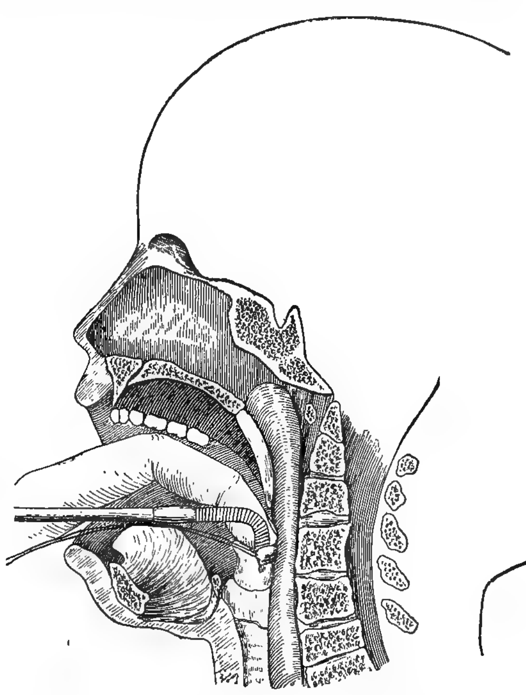


FIG. 2947.—The Tube Passed well into the Larynx. The introducer flat on the tongue.

duction; the left forefinger is placed on the arytenoid cartilages, the epiglottis is hooked up as the finger passes over it, the beak of the extractor is passed to the centre of the pulp of the finger and then to its extreme end, which marks the posterior boundary of the glottis in the median line, and then the handle of the extractor is

abruptly elevated, with the result that the beak of the instrument is pried forward from the finger tip into the opening of the tube. If difficulty is experienced with

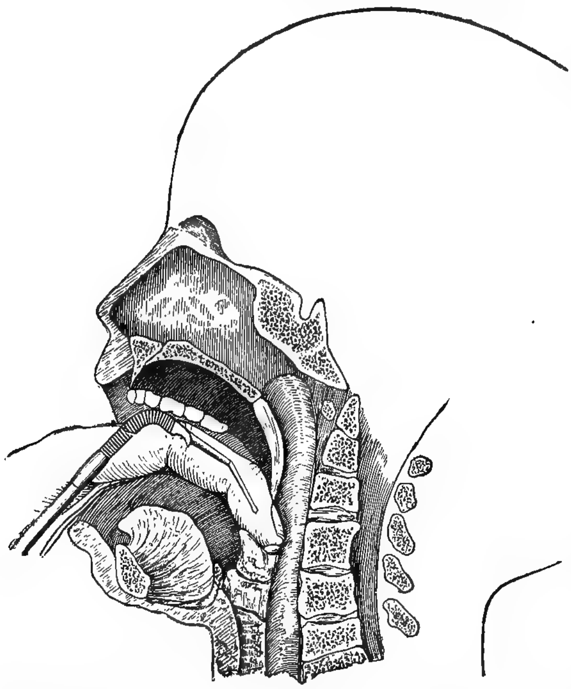


FIG. 2948.—The Left Forefinger Thrusting the Tube in Place and Holding it until the Obturator is Released and Removed from the Mouth.

this method of extraction, the tube may be removed by the same method employed in introducing it, *i.e.*, the extractor is passed along and under the index finger, which is holding back the epiglottis.

Care should be taken to regulate the degree of opening of the jaws of the extractor by means of the guard screw (Fig. 2942, *a*), in order to avoid laceration of the tissues by their wide separation, during ineffectual attempts to find the opening of the tube. The spring of the extractor should not be touched until the beak of the instrument is engaged in the tube. As in introducing the tube, no force is necessary.

Removal of the tube by "enucleation" has been practised to some extent. The short tubes of Bayeux already referred to are better adapted to this method, although the operation is possible with O'Dwyer's tubes. The child is held head downward, while pressure is made on the trachea just below the point of the tube. This operation, while it is not to be relied upon, especially with the O'Dwyer tubes, is certainly worthy of a trial in an emergency, as for instance when there is a sudden blocking of the tube which is not followed by expulsion. In cases also in which the tube has slipped below its proper position, it is perhaps better to try this method rather than risk pushing the tube farther down with the extractor.

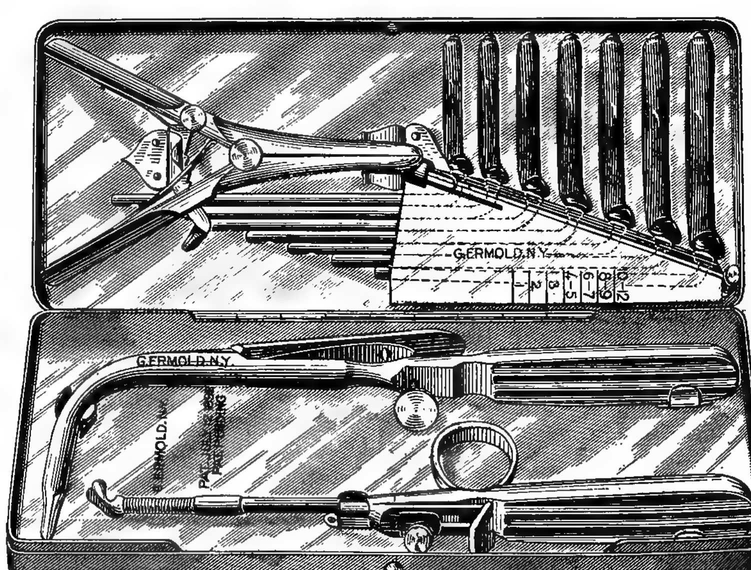


FIG. 2949.—Latest Design of Case Containing a Set of O'Dwyer's Instruments.

When to Extubate.—With the use of antitoxin, the time during which a tube need be retained has been materially shortened and reintubation is much less frequently required. The retention of the tube is dependent on the general condition of the patient, the amount of toxæmia present, the condition of the pulse and temperature, the presence of membrane in the pharynx, and the age of the patient. Children under two years of age usually require the tube for from one to two weeks, older children for five days or less. Blocking of the tube with false membrane or thick mucus is usually an indication for immediate removal. In the majority of such cases the tube is expelled spontaneously. Before resorting to extraction, attempts may be made to get rid of the membrane by giving small doses of whiskey and water in order to excite coughing, or the child may be inverted and struck sharply on the back.

Dangers and Difficulties of the Operation.—There are no dangers to life at the hands of an expert operator from the operation itself. No physician should undertake to intubate a living child without thorough practice on the cadaver. Without such experience, tracheotomy is much to be preferred, for the field of operation is then beneath the eye of the physician. Dangers from the operation in unskilled hands are: asphyxia from prolonged and awkward attempts at intubation, laceration of the soft parts, with the extractor as well as the tube, and the making of false passages, generally through the ventricles of the larynx.

"Pushing down false membrane" has been erroneously made responsible for many deaths during the operation. This accident occasionally occurs, in which case the tube should be quickly removed by the still attached string when the membrane will usually be expelled. In some cases it may be necessary to use false membrane tubes for a little while.

Subglottic stenosis (so-called œdema) may rarely be the cause of difficulty in performing intubation. This occurs at the cricoid division of the larynx (the narrowest part) and may necessitate a certain degree of force in order to push the tube through the constriction.

Retained Tube.—Conditions requiring frequent re-intubations are: persistence of the laryngeal membrane, œdema, ulcerations about the cricoid cartilage, leading occasionally to collapse of the cartilaginous framework of the larynx, cicatricial contractions, granulations, and abductor paralysis.

Care and Feeding of Intubated Children.—In the majority of cases of intubation the children soon learn to take food in the ordinary way. If, however, this is not possible, Casselberry's position may be necessary at least for a short time. In this method the patient's head hangs back over the lap of the nurse at an angle of forty-five degrees, the feet are elevated on a chair, and food is given with a spoon or from a bottle.

Gavage is preferred by some physicians during the entire time of intubation. It is certainly contraindicated when the pharynx is congested and painful. Rectal feeding should be regarded as a last resort. Semi-solids are more easily taken than liquids. Food should be given at short intervals and in such quantities as the child will take.

Nasal irrigation in cases of concurrent nasal diphtheria, is not contraindicated in intubated cases. Pharyngeal irrigation had best be omitted. To avoid the necessity of reintubation Dover's powder, gr. i., or morphine sulphate, gr. $\frac{1}{20}$–$\frac{1}{12}$, may be given a short time before the tube is removed, and repeated afterward if necessary. Other useful measures to the same end are hot poultices over the throat, hot baths, and steam inhalation. Calming and amusing the child are also of great service.

The more recent statistics of intubation show that with the early use and proper dosage of antitoxin the operation detracts but little if at all from the chances of recovery from laryngeal diphtheria. Thus Waxham has reported forty intubations, with a mortality of five per cent.

The advantages of intubation over tracheotomy are in brief: That the former is bloodless, requires no anæsthetic or the help of trained assistants, is performed in a few seconds, and the after-care of the patient is much less than in tracheotomized cases. Finally, it would seem to be very poor judgment on the physician's part to inflict an open wound in order to tide a patient over a difficulty often (with the use of antitoxin) of only a few hours' duration.

Intubation for the relief of chronic stenosis due to cicatrices from wounds, syphilitic lesions, etc., as well as for the removal of a retained tracheotomy cannula, was suggested and practised by Dr. O'Dwyer with excellent results. The details of the operation cannot here be entered into. Suffice it to say that its success depends largely on the ingenuity and skill of the operator in having tubes fashioned to the various conditions encountered.

William P. Northrup.
Matthias Nicoll, Jr.

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INTUSSUSCEPTION.—The prolapse of one part of the intestine into the lumen of the adjoining part is called an intussusception. The included portion is called the intussusceptum, the receiving portion the intussuscipiens.

The condition is uncommon, and many physicians of large experience have never seen a single case. Among 12,641 cases of disease of which the diagnosis is recorded in recent hospital reports in New York City, there are only two such cases. Much attention, however, has recently been called to the condition, and the increasing number of reports suggests that when the possibility of this condition is in the mind of the examiner the diagnosis will be made more frequently.

CAUSE.—Little is definitely known of the cause of intussusception. In peristalsis there are temporary contractions of the circular muscle fibres of the intestine. It is easily conceivable that in rare instances, under certain irritations, this contraction should be prolonged and that the contracted part, with or without the action of the longitudinal fibres, should slip into the lumen of the adjacent part of the intestine and thus form an intussusception; and it is generally believed that most intussusceptions are formed in this way. A polypus or other new growth or a foreign body may also drag on the intestine and thus invaginate it. Leichtenstern,[1] in studying the records of 320 cases, found that polypi were present in 30 and that in 34 others there were cancers, strictures, masses of undigested food, or other foreign bodies.

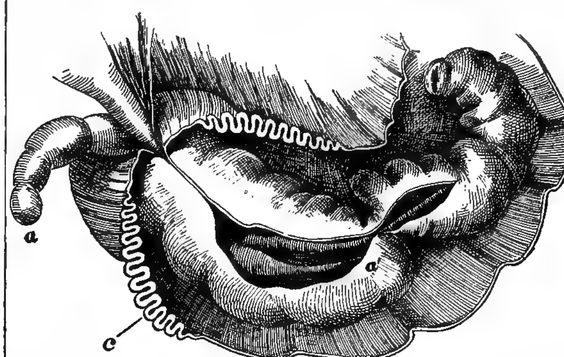

FIG. 2950.—Intussusception. (After Braun.) The lower end of the ileum, the cæcum, and a part of the colon have prolapsed into the colon. *a*, Appendix vermiformis; *a'*, cæcum; *c*, wrinkling of sheath which permits much mobility.

Occurrence.—The condition occurs generally in children. Curtis,[2] in his comprehensive article in the former edition of this work, gives the following table of ages:

Age.	Acute cases. Per cent.	Chronic cases. Per cent.
Before 11 years	53	28
Between 11 and 20 years	12	10
Between 21 and 40 years	20	47
Between 41 and 60 years	11	12
Over 60 years	4	4

He found that children not over one year of age furnish 29 per cent. of the cases of intussusception.

The *location* of the intussusception is most commonly at the ileo-cæcal opening.

Leichtenstern found the following distribution: Ileocæcal, 44 per cent.; enteric, 30 per cent.; colic, 18 per cent.; ileo-colic, 8 per cent. The cases of intussusception in the small intestine were almost entirely confined to the ileum and the lower part of the jejunum. There are, however, records of a very few rare cases of intussusception of the duodenum.

Curtis noted that three-fourths of the cases in children under one year of age were ileo-cæcal, the mobility of the cæcum and entire colon being greater in early life.

SYMPTOMS.—The symptoms which are most commonly present are the following: 1. Abdominal pain. 2. Vomiting. 3. Constipation. 4. The presence of a tumor within the abdomen. 5. The passage of blood and mucus from the rectum. 6. The presence of the intussusceptum so near the rectum that it can be felt by the finger. 7. Shock.

Pain usually comes on suddenly, often without any preceding illness or injury. The patient usually twists and turns until he has reached the position which is least uncomfortable, possibly flexing the thighs on the body.

Vomiting is usually persistent, first of the stomach

contents, then of the intestinal contents; the character of the material vomited depends on the site of the constriction, and it need not be distinctly fæcal. Persistent vomiting should always lead one to examine very carefully for the other symptoms of intussusception.

Constipation must of course be present when the intestine is occluded, but the contents of the intestine which are below the occlusion come away with the enemata, and this may be misleading during the early hours of the condition.

Abdominal Tumor.—The intussusception may frequently be felt within the abdomen. It is generally described as a sausage-shaped mass, usually lying near the ileo-cæcal region. The possibility of feeling it depends largely on the presence or absence of inflammation and tympanites. If there is enough inflammation to cause reflex rigidity of the abdominal muscles, it may be difficult or even impossible to feel the mass; if this rigidity is excessive and if there is tympanites, it will probably be impossible to distinguish the mass without putting the patient under the influence of an anæsthetic. Sometimes a very long piece of the ileum slides into the colon, and it may even pass through its entire length as far as the rectum; in such instances instead of a sausage-shaped tumor there would be a tumefaction throughout the entire length of the colon, which might be very indefinite to the touch. Again, in very rare instances the intussusception is in the upper part of the intestine close under the liver, where it cannot be felt. It may be under the ribs, and hence impalpable, even when it is located lower in the small intestine. Erdmann[3] states that in three of his nine cases no tumor could be found before operation, although the ablest of pediatric diagnosticians had carefully palpated the subjects. Operation was, however, performed on account of the symptoms, and in two of the cases the tumor was found under the ribs in the left hypochondriac region; in the third it was under the right lobe of the liver.

The Passage of Blood or Bloody Mucus from the rectum is a most important aid to diagnosis. When it occurs in conjunction with the symptoms already enumerated, it makes the diagnosis almost certain. In the cases in which operation has been done it has been among the most commonly recorded symptoms. In 150 cases studied by Gibson,[4] in which the record of symptoms was not complete, a bloody discharge from the rectum was recorded 38 times; vomiting, 25 times; intussusception felt through the rectum, 23 times; discharge of mucus, and tenesmus, 12 times.

The Palpation of the Intussusception through the Rectum is of course proof positive of its existence; an effort should always be made to feel it there in suspected cases. Its presence is recorded in one-sixth of the cases in Gibson's table.

Shock and Exhaustion may or may not be present. Curtis states that as a rule the little patients remain in good condition until suffering and want of food lead to exhaustion. The writer's experience corresponds to this. Erdmann found shock present in the majority of his cases.

One cannot expect to find all of these symptoms in a single case, but a routine search should be made for all of them in every child who has persistent vomiting.

TREATMENT.—Success in the treatment of this condition depends largely upon promptness in diagnosis. There is hardly a condition in medicine or surgery in which an early and definite diagnosis is more important for the patient. Before adhesions have formed, the intussusception can be reduced with ease. When firm adhesions have formed, reduction is difficult. When the intussusception has become gangrenous, the condition is one of the most formidable known to surgery.

Only two methods of treatment need be considered: (1) The injection of liquids or gas by the rectum; and (2) operation. The operative method is coming more and more into prominence; the use of enemata is being made more subordinate each year. Many children have died under treatment by enemata who could have been saved by prompt operation.

The objections to enemata may be thus stated: (1) They may delay operation until it is too late; 2, they may rupture the intestine; (3) it is very difficult to determine whether the intussusception has been reduced by them; (4) if the intussusception has been reduced, it is much more likely to recur than when a fold has been made in the mesentery and stitched according to Senn's method. These objections are based upon the records of cases. Gibson, whose entire tabulation includes two hundred and thirty-eight cases in which operation has been done, gives examples to show how real they are.

The first objection is perhaps the most important. If the diagnosis is once made, relief should be obtained without delay; an intussusception should be dealt with as promptly as a strangulated hernia, and the giving of enemata and waiting to study the result is apt to cause most dangerous delay.

The following cases[4] show the danger of perforation: A child of five years (case recorded by Harrington) was given an enema under a hydrostatic pressure of four and one-half feet, on the fifth day of the intussusception, and the ileum was found to be perforated as a direct result of the pressure. Fenwick records a fatal perforation which occurred in a child of six months, following an enema which was given on the second day of the illness. Reduction apparently occurred, but the child died almost immediately, and the autopsy showed ulceration and perforation of the gut, the intussusception not having been reduced. Parkes cites a case in which an injection of one pint in a three-months-old child caused a perforation in the lower part of the intussusception, which was found at the autopsy.

A change in the size or location of the invagination or a partial reduction may be easily mistaken for a complete reduction. Instances of this are also recorded in Gibson's tables.

Gibson also calls attention to many instances of the return of the intussusception after it had once been reduced by enemata. Of course this may occur after operation, but if the mesentery is folded longitudinally and then stitched it is less likely to do so.

The following rules for the use of rectal injections may be given:

1. Only water or bland liquids should be used, since the pressure of air or other gases cannot be accurately measured.

2. The column of liquid should not be more than three feet high. Pick[4] limits the height to three feet and the amount to one and one-half pints for a child under one year of age.

3. Enemata should be used only in the early stages of the intussusception. Gibson would limit their use to the first two days. He found that in at least three of the cases recorded as treated on the first day of the disease, more than a simple reduction of the intussusception was needed; in one of them the colon was beginning to slough. Erdmann considers the use of enemata justifiable in all cases of less than twenty-four hours' duration.

4. If the enema is to be given, all the preparations for operation should be made, and unless there is definite proof that the intussusception has been reduced the abdomen should be opened.

Operation.—The operation of choice is the opening of the abdomen and the reduction of the intussusception by manipulation and pressure from below without pulling on the intestine. A plait may then be stitched in the mesentery in the hope of preventing a recurrence.

The use of enemata to aid in this reduction after the abdomen has been opened may be of very great assistance. Brewer[5] reports a case of five days' duration in which a part of the ileum, the cæcum, and nearly half of the colon had prolapsed into the remaining part of the colon so as to be palpable at the rectum; dense adhesions were present, but the patient was put in the Trendelenburg posture and the rectum distended by saline solution. By the combined use of taxis, traction, pressure of saline solution, and the manual breaking up of adhesions be-

tween the ileum and colon, the intussusception was finally reduced and the patient recovered.

There are many instances in which the reduction of the intussusception has been impossible. The intestinal wall, when deprived of its circulation and subjected to so much pressure, becomes weakened and may rupture even under very gentle manipulation; or the operator may see that further manipulation will rupture it, and hence decide to do a resection at once.

Under these conditions the following procedures are to be considered:

1. Resection of the diseased intestine and union of its ends by suture or by a Murphy button.
2. Removal of the intussusceptum through a longitudinal opening in the intestine which holds it, and suture of the intestinal walls where the intussusceptum enters the intussuscipiens.
3. The formation of an artificial anus in the hope of restoring the continuity of the intestine at a later time.

Intestinal resection and union of the divided ends is the operation of choice, and will probably save more lives than any other method of dealing with the condition. It has two distinct advantages over the second method: (1) The section may be so placed that healthy parts of intestine are used for approximation; (2) there is the minimum danger of sepsis from handling of the inflamed intussusception.

There are, however, instances in which the second method is preferable. For example, in the case of an intussusception in the large intestine when the lack of mesentery makes approximation of the ends of the intestine very difficult, it may be better to take advantage of adhesions which already exist at the upper margin of the invagination.

It is generally conceded that an end-to-end union is better than a lateral anastomosis, as there is less danger of cicatricial contraction. Whether the end-to-end union should be made with a Murphy button or by suture depends on the practice of the individual surgeon. The present tendency is to use Murphy buttons. In intestinal resection after strangulated hernia they have been of great aid. Peterson,[6] for instance, in studying the cases from Czerny's clinic in Heidelberg, reports 15 cases of primary resection with 8 deaths prior to 1898, a mortality of 60 per cent.; and 12 primary resections with 1 death since 1898, a mortality of 8 per cent. He ascribes the improvement to the use of the Murphy button and to the employment of local anæsthesia.

The conditions in intussusception are not so favorable for the Murphy button. The cases are usually in children and a button of very small size is necessary, and this may be difficult to use in the distended upper part of the intestine, unless it is inserted in the side of the gut. Again, in these operations of emergency the proper button may not be at hand.

End-to-end suture, with the first row of sutures including all the intestinal coats and carried over the intestinal margins, and the second row going to and including the submucous layer, may be relied upon as an efficacious method.

The formation of an artificial anus is not usually to be advised. It is conceivable that in a case of dire urgency the intestine may be drawn through the abdominal opening and left there, but the results from this procedure are very discouraging. Unless the opening is in the lower part of the intestine life is maintained with difficulty, and even then there is an irritating and disagreeable discharge, and the necessity still exists for a secondary operation which of itself has a high mortality rate. Peterson [6] has recently considered with great care the relative advantages of intestinal resection and artificial anus in cases of strangulated hernia. The mortality in 22 artificial-anus cases was 67 per cent., and in 28 resection cases 33 per cent. He quotes numerous authorities, among them Zeidler,[7] who has analyzed 213 cases treated by artificial-anus formation and 269 cases treated by intestinal resection, and concludes that the higher mortality rate of the former was not due to the nature of the cases prior to operation. He suggests that an additional 17 per cent. of the artificial-anus cases could have been saved by intestinal resection.

Prognosis.—The mortality from intussusception is very high, but it is diminishing from year to year. In the former edition of this work Curtis stated that it was 76 per cent. in 70 patients who had been operated upon from 1873 to 1887 inclusive. In 1891[8] he found it 70 per cent. in 105 cases. In 1897 Gibson found it 53 per cent. in 149 patients operated upon from 1888 to 1896 inclusive.

A reduction from 76 to 53 per cent. is most encouraging. Still we must look with terror on a disease which has a mortality of 53 per cent.; and when we realize that the mortality would probably be less than 10 per cent. if an early diagnosis could always be made, we must be impressed with our responsibility and the importance of considering all the elements which go to make this diagnosis; and we must realize the necessity for prompt action if the diagnosis is once made.

There is an enormous difference in the mortality of reducible and irreducible cases. Gibson found the former to be 38 per cent., the latter 82 per cent. He found only 10 cases of recovery after irreducible intussusception in his entire series of 238 cases dating back to 1869. There was no case of recovery from irreducible intussusception in a child under seven years of age. There was only one case of recovery from gangrenous intussusception; it was in a patient twenty-three years of age.

These figures, however, do not indicate the possibilities of intestinal surgery at the present time. Ludloff[9] reports four cases of intestinal resection and end-to-end suture for intussusception, with recovery. A fifth case was treated by intestinal anastomosis and terminated fatally. In a sixth case the invagination was reduced with difficulty, and abscesses formed about it, but there was final recovery.

The writer[10] has been so fortunate as to obtain a recovery from gangrenous intussusception of ten days' duration, in a boy four years old, by intestinal resection and end-to-end suture. We may confidently expect that we shall in the future know of many cases of recovery from irreducible intussusception.

The space allotted to this article does not allow of an exhaustive consideration of all the topics. For such a consideration the reader is referred to the literature to which references are made. *Charles N. Dowd.*

[1] Leichtenstern: Vierteljahrschr. f. prakt. Heilk., 1873.
[2] Curtis: Reference Handbook of the Medical Sciences, New York, 1889, vol. viii.
[3] Erdmann: Annals of Surgery, July, 1900, p. 183.
[4] Gibson: Medical Record, July 17th, 1897, p. 72.
[5] Brewer: Annals of Surgery, September, 1900, p. 249.
[6] Peterson: Deutsch. med. Woch., 1901, Nos. 8–10.
[7] Zeidler: Cent. Chir., 1893, p. 62.
[8] Curtis: Medical Record, 1891, xl., p. 534.
[9] Ludloff: Centralblatt für Chir., 1899, p. 46.
[10] Dowd: Annals of Surgery, July, 1902.

INVERTIN.—An enzyme contained in the *succus entericus* which possesses a powerful hydrolyzing or inverting action upon cane sugar and maltose, causing in each case the taking up, by the disaccharide molecule, of the elements of a molecule of water and simultaneous cleavage into two monosaccharide molecules. There is thus formed in the case of cane sugar a mixture of equal quantities of dextrose and lævulose, *i.e., invert sugar*, and, in the case of maltose, dextrose alone in equivalent quantity is formed. The enzyme is stated to be inactive toward lactose, although it is present in the intestinal secretion at birth.

That the action is due to an enzyme is shown by the facts that it is not inhibited by the presence of antiseptics, and is at once destroyed by boiling the *succus entericus*.

Benjamin Moore.

IODANTIFEBRIN.—$C_6H_4INHC_2H_3O$. This is prepared from acetanilid by substituting iodine for one hydrogen atom. It was prepared by Dr. Ostermayer, who also introduced iodantipyrin. It is a white crystalline powder insoluble in cold, but soluble in hot water

and alcohol. The experiments of Dr. Ostermayer showed that it was devoid of any therapeutic action. No effects were observed that could be attributed either to the acetanilid or to the iodine, nor could either be detected in the urine after its administration. It appears that the iodine destroys the solubility of the compound and that no absorption takes place. *Beaumont Small.*

IODANTIPYRIN; IODOPYRIN.—$C_6H_4I(CH_3)_2C_3HN_2O$. This compound, introduced in 1891 by Dr. Ostermayer, is antipyrin in which one hydrogen atom has been replaced by iodine. It forms in colorless, shining, prismatic needles, not very soluble in cold water or alcohol, but readily soluble in either when hot.

Iodopyrin was supposed to be a soluble combination of the therapeutic properties of antipyrin and iodine, but experience has shown that in the stomach it is decomposed by the hydrochloric acid, and forms antipyrin and iodide of sodium. Its antipyretic effects are those of antipyrin. In typhoid fever, pulmonary phthisis, rheumatic fever, and other febrile conditions, it lowers the temperature rapidly, and lowers the pulse and respiration; at times it produces a free perspiration. The dose is from seven and a half to twenty-two grains. The value of the iodide of sodium is uncertain, as no decided benefit has been traced to it. The iodine may be detected in the urine after fifteen to twenty-two grains have been given. *Beaumont Small.*

IODIDES.—I. General Medicinal Properties of Iodides.—Iodides whose basic radicle is sufficiently innocent to permit of the taking of the salt in decided quantity show special and marked physiological and therapeutic powers, unquestionably due to the iodine of their composition. Physiologically, they tend to produce symptoms as of catarrh, affecting sometimes the mucous membranes of the head alone, and sometimes also the gastro-intestinal mucous tract; to bring out an acneform eruption on the face; and, when given in large doses long continued, to favor emaciation. These derangements, constituting the condition known as *iodism,* present themselves clinically as follows: The subject experiences the general feeling of discomfort preceding feverishness, and soon follow running at the nose and watering of the eyes, with frontal headache and sneezing. In sensitive persons the conjunctiva may be blood-shot, and the circumjacent tissues swollen and œdematous. A salty taste is perceived, and the salivary flow is somewhat freer than usual. From extension of the influence to the lower mucous membranes, there may develop cough, with hoarseness, from irritation of the throat, and epigastric sinking, with nausea, and a watery diarrhœa, with colic, from affection of the gastro-intestinal tract. An eruption, like acne, is apt to break out, first upon the face, where the papules are generally large and indurated, and later upon the trunk or extremities. Sometimes purpuric blotches also appear, or blebs, and sometimes the main eruption is eczematous instead of acneform. Nervous symptoms are not so very uncommon, of the general type of listlessness and depression, and in one case of long-continued heavy dosage H. C. Wood observed the subject to be "intensely sleepy and stupid," as in the allied condition of bromism. As regards the tendency to emaciation, this certainly is insignificant, even in the very large dosage with iodides of current medical practice; and the alleged atrophy of the mammæ or the testicles under the influence of the iodides, if it happens at all, is so exceedingly rare that it may be dismissed from consideration as a possible danger in the use of the medicines. An important point in connection with the phenomena of iodism is the very different susceptibility of different individuals, on the one hand, and of the same individual at different times, on the other. Thus, with some, coryza is developed by doses of only a few centigrams each (between one and two grains), and, with some, the disagreeable symptoms spontaneously subside, even during a continuance of the medication. In persons who are keenly susceptible, the necessary therapeutic dosage may be attained by beginning with very small doses, such as 0.03 gm. (half a grain) of an alkaline iodide, and gradually increasing. Under any circumstances, the taking of copious draughts of fluid during the course of the medication tends to lessen both the frequency and severity of possible iodism doubtless by hastening the elimination of the iodide salt. And even when occurring, the phenomena of iodism are, with rare exceptions, distressing rather than dangerous, and disappear promptly and fully upon discontinuance of the dosing.

The therapeutic power of the iodides resides in a tendency to promote the absorption of inflammatory or hyperplastic products. This influence, however, proves to be of very different degrees of potency in the different circumstances where morbid products develop. It is, in general, most powerful where the parts involved belong to the nervous or the connective-tissue structures, and, in particular where the process is determined by the syphilitic, the rheumatic, or the scrofulous cachexia. Over purely idiopathic hyperplasiæ or inflammatory products the resolvent power of the iodides, though often decided, and sufficiently so to be exceedingly valuable clinically, yet is distinctly less pronounced. In affections of epithelial structures, the influence of the iodides is perhaps most marked in bronchocele, and much more so in the idiopathic variety than in that belonging to Basedow's disease; next in scrofulous enlargement of the lymphatic glands; and least in enlargement of the spleen and organic disease of the kidney. To develop the full potency of the iodides it is necessary, more often than not, to give large doses, especially in organic disease of the nerve centres, whether syphilitic or idiopathic. In such cases a marked alleviation of symptoms, or, in possible instances, even a cure, may often be wrought by bold exhibition of an iodide, where previous inadequate dosage had failed to produce any effect whatsoever. In brain disease such quantities as from 8 to 24 gm. (ʒ ij.–vi.) of an alkaline iodide are not unusual daily allowances. Besides the foregoing, iodides have a few special medicinal applications, as follows: In chronic poisoning by mercury or lead, the alkaline iodides, taken internally, tend to determine a reabsorption into the blood, in soluble condition, of such of the mineral as had been fixed in the tissues. Thus elimination of the poison is favored; but thus also acute poisoning may be re-established, if too much of the metallic compound is made to enter the blood at once. Hence, in this particular therapeusis of the iodides, the doses must at the beginning be small, and any increase is to be made gradually and with careful watching of the effects produced.

II. The Iodides Used in Medicine.—The iodides official, or entering into the composition of pharmaceutical preparations official in the United States Pharmacopœia, are, of the heavy metals, the iodides severally of *iron, mercury, silver, zinc,* and *lead;* of the metals of the alkalies and the earths, the iodides of *potassium, sodium, ammonium,* and *strontium;* and of non-metallic elements, the iodides of *arsenic* and of *sulphur.* Of these various iodides, those of the alkali metals and of strontium alone can be given in sufficient dosage to develop the full iodide therapeutic influence. In the other iodides the medicinal effects of the basic radicle practically outshine what can be gotten from the iodine, and such of the list given above as are compounds of heavy metals or of non-metals will therefore be found discussed under the several titles of the basic elements. The group of iodides medicinally important simply as iodides comprises, of the official list, only the potassium, sodium, ammonium, and strontium salts, to whose action alone the foregoing remarks concerning effects and uses apply in full.

Potassium Iodide, KI. The salt is official as *Potassii Iodidum,* Potassium Iodide. It occurs in "colorless, transparent, or translucent, cubical crystals (the white, opaque, commercial variety being crystallized from an alkaline solution, and less pure), or a white granular powder, having a peculiar, faint, iodine-like odor, and a pungent, saline, afterward bitter taste. Permanent in dry air, and but slightly deliquescent in moist air. Solu-

ble at 15° C. (59° F.), in 0.75 part of water, and in 18 parts of alcohol; in 0.5 part of boiling water, and in 6 parts of boiling alcohol; also soluble in 2.5 parts of glycerin" (U. S. P.). The salt should be kept in well-stoppered bottles. Potassium iodide is chemically incompatible with metallic mercury and the pharmaceutical preparations containing mercury in that state, and with the oxides, sulphates, and chlorides of the same metal, including mercurammonium chloride ("white precipitate"). In the case of mercuric chloride (corrosive sublimate), however, the chemical incompatibility does not impair the medicinal efficiency or pharmaceutical elegance of a mixture of the two salts in solution; for if, as must be the case in a medicinal prescription, the potassium iodide be in excess, the mercuric iodide forming upon addition of mercuric chloride immediately redissolves through the secondary forming of a double salt. And such solution produces to full degree the medicinal effects of the mercurial. Corrosive sublimate therefore may be prescribed very conveniently in a solution of potassium iodide. Potassium iodide is incompatible with alkaloids, and practically so also with potassium chlorate; for though no reaction occurs at ordinary temperatures when potassium iodide and potassium chlorate alone are mixed, yet upon the addition of a mineral acid iodine is liberated and apparently iodic acid is formed in the solution. And, according to Melsens, the giving to dogs of potassium iodide and chlorate in conjunction leads to speedy, and even possible fatal, poisoning, presumably because of the occurrence of some such reaction as just described.

Potassium iodide is the best known and most used of the alkaline iodides, and is commonly considered the most effective one of the group. Being a salt of potassium, and one given medicinally in large doses, it produces, in addition to the typical effect of the iodides, those peculiar to potassic salts as such. Accordingly, full doses may depress, generally, and in particular, may weaken heart action: may be diuretic, and, if swallowed in strong solution, be decidedly irritant to the stomach. As regards the diuretic effect, upon which much stress is often laid, this occurs to about the same degree as with other potassic salts, such as the citrate or acetate (see Potassium), a degree which, though not very pronounced, yet may lead to valuable clinical results; for the diuresis often will favor the resolvent effect of an iodide, so that, where dropsy is a feature of a case for which an iodide is to be prescribed, the potassic salt is peculiarly the one to be selected. As to the gastric irritation apt to follow large doses of potassium iodide, this is a well-recognized feature of the action of the salt if the same be given in strong solution; but by the simple device of making the solution quite dilute, this and also all other symptoms of iodism are rendered much less likely to occur. According to Seguin,[1] the tendency to stomach derangement is still further lessened by giving the iodide in a slightly alkaline and also effervescing water, such as Vichy, or, where this is not obtainable, in the same quantity of plain water alkalized by a pinch of sodium bicarbonate.

Potassium iodide is absorbed and eliminated rapidly, and is available for all the purposes of the iodides as set forth in the first section of this article. As to dosage, it is rare that any useful effect follows a smaller daily allowance than 1 gm. (gr. xv.); generally, indeed, from two to three times such quantity will be necessary; and very often—notably in organic affections of the central nervous system—the daily quantity must be pushed rapidly to a range between 8 and 24 gm. (ʒ ij.–vi.), else a valuable, possibly even curative effect will wholly be missed. In all cases the daily allowance should be broken up into at least three doses; and, especially where the quantities are large, the precautions of giving the salt in an abundance of fluid, and also of giving frequent draughts of water during the whole period of the medication, should carefully be observed. For a vehicle, the one described above is decidedly preferable to the syrupy mixtures so often prescribed, and what other medicines may also be indicated in a given case are best administered by themselves at different times from the iodide. The United States Pharmacopœia makes official *Unguentum Potassii Iodidi*, Ointment of Potassium Iodide, containing twelve per cent. of the salt incorporated in benzoinated lard. The ointment is designed for the local treatment of surface indurations.

Sodium Iodide, NaI. The salt is official as *Sodii Iodidum*, Sodium Iodide. It occurs as "colorless, cubical crystals, or a white, crystalline powder, odorless, and having a saline and slightly bitter taste. In moist air it deliquesces and becomes partially decomposed into sodium carbonate and free iodine, assuming thereby a reddish color. Soluble, at 15° C. (59° F.), in 0.6 part of water, and in about 3 parts of alcohol; in 0.33 part of boiling water, and in 1.4 parts of boiling alcohol" (U. S. P.). The salt should be preserved in well-stoppered bottles.

Sodium iodide bears to the potassium salt the usual relation of a sodic to a potassic chemical brother. It is less depressing, less irritating, and less diuretic, but also, though efficient enough in ordinary cases, is less reliable in those cases that test medicinal potency most severely. The salt is to be given in the same doses as potassium iodide, and with the observance of the same precautions.

Ammonium Iodide, NH_4I. The salt is official as *Ammonii Iodidum*, Ammonium Iodide. It occurs as minute, colorless, cubical crystals, or a white, granular powder, without odor when colorless, but emitting a slight odor of iodine when colored, and having a sharp, saline taste. The salt is very hygroscopic, and soon becomes yellow or yellowish-brown on exposure to the air and light, owing to the loss of ammonia and the elimination of iodine. Soluble at 15° C. (59° F.), in 1 part of water and in 9 parts of alcohol, in 0.5 part of boiling water, and in 3.7 parts of boiling alcohol. When heated on platinum foil, it evolves vapor of iodine and volatilizes completely without melting" (U. S. P.). From the proneness of this salt to deliquesce and to generate free iodine, the Pharmacopœia enjoins that it be kept in small, well-stoppered bottles, protected from light, and that samples deeply colored be not dispensed until deprived of free iodine by proper treatment.

Ammonium iodide exhibits the usual properties of the iodides, and may be used for the usual purposes. As usual, contrasting ammonic with potassic salts, the ammonic is less depressing than the potassic, but is inconvenient because of its readiness to decompose with the objectionable evolution of free iodine. Ammonium iodide is generally prescribed in smaller dosage than the potassic salt, the daily average being from 1 to 2 gm. (gr. xv. to xxx.). It should be given in plenty of fluid, and the solutions should not be kept too long, and while kept should be well protected from light.

Strontium Iodide, $SrI_2,6H_2O$. The salt is official as *Strontii Iodidum*, Strontium Iodide. It occurs in "colorless, transparent, hexagonal plates, odorless, and having a bitterish, saline taste. Deliquescent, and colored yellow by exposure to air and light. Soluble in 0.6 part of water at 15° C. (59° F.), and in 0.27 part of boiling water. Also soluble in alcohol and slightly in ether" (U. S. P.) The salt should be kept away from the light, in dark amber-colored, glass-stoppered vials.

Strontium iodide acts like the iodides of the alkalies, but is more slowly absorbed, and is believed to have less tendency than the potassium iodide to irritate the stomach or intestines. It is given in solution, in doses ranging from 0.32 to 1 gm. (gr. v. to xv.). *Edward Curtis.*

[1] E. C. Seguin: Archives of Medicine.

IODINE.—Iodine is official in the United States Pharmacopœia as *Iodum*, Iodine. It is described as "heavy, bluish-black, dry and friable, rhombic plates, having a metallic lustre, a distinctive odor, a sharp and an acrid taste. . . . Iodine imparts a deep-brown, slowly evanescing stain to the skin, and slowly destroys vegetable colors. Soluble in about 5,000 parts of water, and in ten parts of alcohol at 15° C. (59° F.) with a brown color; also freely soluble in ether, and in a solution of

potassium iodide with a brown color, and in chloroform or carbon disulphide with a violet color" (U. S. P.). Iodine volatilizes slowly, even at ordinary temperatures, and, upon heating, melts and is dissipated, without residue, in violet-colored fumes. With starch paste it produces a characteristic dark blue color. Iodine must be kept in glass-stoppered bottles, in a cool place. The commercial sources of iodine, at the present time, are mainly the native beds of sodium nitrate in South America, where sodium iodate occurs in association with the nitrate salt. Some iodine, however, is still prepared from kelp—the ashes of burnt sea-weeds.

Iodine, like its chemical congeners, chlorine and bromine, has an affinity for hydrogen, but its action, because of this affinity, in decomposing compounds containing hydrogen is not so pronounced as in the case of chlorine or of bromine. Probably, mainly because of this affinity for hydrogen, vapor of iodine is deodorant, and iodine solutions applied directly to foul and infectious matter prove both deodorant and disinfectant. Sternberg,[1] experimenting with the micrococcus of gonorrhœal pus, found iodine to be antiseptic (*i.e.*, inhibiting development) in solutions of the strength of one part to four thousand (one-fortieth per cent.), and permanently germicidal in solutions representing one part to five hundred (one-fifth per cent.)—percentages which, as compared with those of other so-called antiseptics similarly studied, show for iodine a high germicidal potency. As regards the effects of the element upon the living animal system, iodine is locally irritant and even caustic; and taken into the stomach, is readily absorbed and produces constitutional effects similar to those of the alkaline iodides (see *Iodides*). Many consider, indeed, that the greater part of a dose of iodine finds entrance into the blood in the condition of sodium iodide. Others hold that probably some, at least, of the iodine enters into combination with albumin, and is absorbed in the state of the compound so formed. The local effects of iodine, which medically are of more importance than the constitutional, are in detail as follows: Applied to the skin, iodine solutions stain the cuticle a yellowish-brown and excite some tingling, pricking, or, if strong, even smarting. The stain tends spontaneously to disappear, and, if the application has not been too strong, some desquamation of the epidermis is the only physiological after-effect. If, however, a strong solution is used, or if repeated applications are made upon the same spot, the skin may inflame and blister, with the production of a very painful sore, or even may be destroyed. In all cases the healing action following the direct effects of the iodine is rapid and kindly. Upon serous membranes iodine easily induces an active inflammation, which, if the application has not been too severe, is almost certainly of the adhesive character, leading to permanent agglutination of the opposing surfaces. Upon mucous membranes, also, iodine solutions produce considerable irritation, and, if swallowed, may cause dangerous, and even fatal, irritant poisoning. But from the pronounced color and taste of such solutions, accidental or criminal poisoning is unlikely, and iodine is not well enough known as a poison to be selected for purpose of suicide. In case of poisoning, substances containing starch should freely be given as the best antidote, and the symptoms treated upon general medical principles.

An important question is the possibility of absorption of iodine from local surface applications of its solutions. That it can be absorbed by serous surfaces is beyond doubt, since a case has been reported in which fatal poisoning, with constitutional symptoms, followed an injection of an iodine solution into an ovarian cyst. When applied to the unbroken skin, it is possible that, if the solution contain also an alkaline iodide (by whose presence iodine becomes soluble in aqueous fluids), a little iodine may be absorbed; but if a simple alcoholic solution of iodine be employed, theoretical considerations are certainly against the probability of absorption, and, so far as the writer knows, absorption under these circumstances has never been demonstrated by the chemical detection of iodine in the secretions. It is most probable, therefore, that what therapeutic effects follow from painting the skin with tincture of iodine occur simply as reflexes of the local irritation.

The constitutional effects of iodine are substantially similar to those of the alkaline iodides. The main point of difference is, as might be inferred, that iodine will cause more gastro-intestinal irritation than will the iodides. The alleged occasional atrophy of the breasts or of the testicles following prolonged iodizing, in the case of Swiss *crétins*, is also more commonly averred of administration of iodine than of iodides. As used in America, however, the writer does not know of any authenticated case of such atrophy fairly attributable to iodine. The therapeutic effects of constitutional iodizing are also similar in kind to those obtained by the giving of iodides (see *Iodides*); but, perhaps more from habit than from any demonstrated advantage, iodine is often preferred to iodides for the treatment of scrofulous affections and of goitre.

Therapeutically, iodine is a possible disinfectant and deodorant for privies and drains, but unfortunately is too costly for any use requiring considerable quantities. Applied to the skin, solutions of iodine may be used to destroy life or arrest development of the organisms in parasitic skin disease, such as ringworm, although they are not so powerful for the purpose as mercurials; to set up healthy action in sluggish sores; and, painted in repeated coatings over the sound skin, to operate by ordinary counter-irritation for the allaying of pains or for the resolution of engorgements, reabsorption of hyperplasiæ, or abatement of chronic and sluggish inflammations in underlying parts. For the purposes of the latter general category, however, iodine is certainly no better than other agents of equal irritant power; and its selection, because of an assumed specific iodine influence, constitutionally, is futile. To serous surfaces iodine solutions are applied in order to excite adhesive inflammation for the purpose of obliterating a serous tract, as, for instance, in cases of hydrocele, or of spina bifida, or of knee-joint effusion, or even in cases of pleurisy with effusion, or of empyema. But in the case of serous cavities of considerable extent and importance, iodine injections, even when the solutions are fairly dilute, are risky, and many cases are on record of undue irritation, of serious constitutional reaction, and even of death, following such procedures. Internally, iodine is given almost exclusively for its constitutional effects, namely, for the determining of healthier nutritive ways in chronic diseases of nutrition, particularly those of so-called strumous character, and in goitre. Because of the gastric irritation it so easily excites, iodine is not so available for full iodizing as are the alkaline iodides. In the treatment of syphilis, rheumatism, organic affections of the central nervous system, etc.—conditions calling for heavy dosage—the iodides are nowadays quite generally, and quite properly, preferred to iodine.

For use, iodine may be dissolved in alcohol, or, by the addition of potassium iodide, in water or glycerin. "Morton's solution," employed by Dr. Morton, of Glasgow, and others, for injection in cases of spina bifida, consists of ten grains of iodine and thirty of potassium iodide to an ounce of glycerin. Of this, from twenty-five to thirty minims have been injected into the sac in the affection in question. In this country the official preparations are almost exclusively employed, and are as follows:

Tinctura Iodi, Tincture of Iodine. This preparation is a simple seven-per-cent. alcoholic solution of iodine. It should be kept in well-stoppered bottles. Tincture of iodine is a dark-brown, limpid fluid, of a strong odor and taste of iodine. It stains skin and fabrics a rusty brown, and is strong enough of iodine to blister the skin if repeatedly applied to the same area, to inflame serous surfaces, and, swallowed clear, dangerously to irritate the gastro-intestinal tract. It precipitates with water, from the very feeble solubility of iodine in that fluid. Because of this fact the tincture is not eligible for internal giving, and its use is limited to local application. For the treat-

ment of skin disease, or for counter-irritation, the tincture may be used without dilution, lightly painted upon the part with a camel's-hair brush. If the skin be not too sensitive two coats may be laid on, the second as soon as the first has dried—which result happens in a few seconds, from the speedy evaporation of the alcohol. Such paintings may be renewed in the course of two or three days, but must not be made too often over the same area, else blistering and a painful sore will result. For injection into serous cavities tincture of iodine must be diluted, the degree depending upon the area and importance of the tract to be affected, but ranging from twofold to tenfold. The fluid for the dilution is water, to which, to prevent the precipitation of the iodine, potassium iodide must be added in proportion about equal to sixteen per cent. of the quantity of tincture taken for the mixture. In some cases, as of spina bifida, and even empyema, some practitioners have injected small quantities (from 2 to 4 gm. [♏ xxx. to lx.]) of undiluted tincture of iodine.

Under the title of *decolorized* or *colorless tincture of iodine*, preparations are made in various ways, in all of which the addition of water of ammonia to tincture of iodine is an essential feature. Such preparations are indeed colorless, but they are no longer tinctures of iodine in the sense of containing iodine uncombined, since most of the iodine in these solutions exists in combination with the ammonia as ammonium iodide. The preparation of this character of the German Pharmacopœia is compounded of iodine, sodium "hyposulphite," spirit of ammonia, water, and alcohol. The resulting composition is complex, but the essential ingredient is ammonium iodide.

Liquor Iodi Compositus, Compound Solution of Iodine; Lugol's Solution. This preparation is a joint aqueous solution of iodine and potassium iodide, containing five per cent. of the element and ten of the salt. It must be kept in glass-stoppered bottles. This solution is dark-colored and stains like the tincture, but, unlike that preparation, does not precipitate on admixture of aqueous fluids. It is intended for internal taking, and is indeed the only preparation of free iodine ordinarily so administered. The dose is about 0.30 gm. (♏ v.) several times a day, largely diluted with water.

Unguentum Iodi, Iodine Ointment. This ointment consists of four per cent. of iodine and one of potassium iodide, smoothly incorporated with benzoinated lard. The iodine and iodide are first rubbed with a little water, whereby the iodine is more ready to mix with the lard. Iodine ointment should always be made fresh when wanted, since it suffers spontaneous change upon keeping. It is of a deep-brownish color, stains the skin yellow, and exerts thereupon a moderate iodine effect.

Under the name of *iodized starch* there was formerly official the peculiar substance that results from treating starch with free iodine in the presence of water. The compound so forming is dried, powdered, and put up in glass-stoppered vials. This powder readily yields free iodine, while being itself locally quite bland, and has been used as an internal medicine from which to get the constitutional effects of iodine without local irritation. It has been advised in heaped-teaspoonful doses, given in water gruel several times a day.

Iodine Trichloride, ICl_3, is a compound of the two sister substances iodine and chlorine, possessing properties due to both elements. It occurs in yellow or orange-yellow needles, which fume on exposure to air, melt at 33° C. (91.4° F.) and, on further heating, decompose into iodine monochloride and free chlorine. In contact with organic matter the substance rapidly decomposes, yielding free iodine and chlorine. It is freely soluble in both alcohol and water, and, in an excess of water, again decomposes. Mainly by virtue of its yield of chlorine, iodine trichloride is strongly antiseptic and disinfectant, and may be used for local antiseptic purposes in solution of from one to five per cent. strength. It is not official in the United States Pharmacopœia (1890).

Iodantifebrin, or *iodacetanilid*, $C_6H_4I.NH(C_2H_3O)$. This compound forms a flaky crystalline powder, melting at 181.5° C., almost insoluble in water, but soluble in alcohol. Physiologically it appears to be nearly, if not quite, inert, probably because its insolubility in water prevents its absorption. It is not official.

Edward Curtis.

[1] Sternberg: American Jour. of the Med. Sciences, April, 1883, p. 323.

IODINE TRICHLORIDE. ICl_3. A compound introduced by Langenbuch, of iodine and chlorine, made by passing chlorine gas over iodine. A solution may be prepared by dissolving 5.5 parts of iodine in distilled water and passing in chlorine gas as long as it is absorbed. It forms a reddish crystalline powder, hygroscopic, very soluble in water, alcohol, and glycerin, and has a pungent and disagreeable odor. It is a stable compound, and will keep for a long time in powder or in solution; it must be dissolved in distilled water, as any organic matter decomposes it at once. When brought in contact with the pus and secretions of the tissues, it is at once decomposed and its constituents are eliminated. It is a powerful antiseptic and bacteriacide; a one-per-cent. solution sterilizes cultures of the ordinary pus-producers—staphylococcus and streptococcus.

Belfield (*Medical Record*, vol. xiii., No. 3) has used it extensively in surgical practice. He considers that it combines the valuable properties of iodoform and hydrogen peroxide. It is a more active antiseptic than iodoform, and is more stable than the peroxide, remains longer in contact with the parts, and sterilizes all moist animal tissues as well as pus. Its disadvantages are its caustic properties when used in strong solutions, and its injurious action on instruments and clothing. It must be kept from the light and air. It has been used in various tuberculous diseases and all forms of suppuration, and in all it has proved of decided value. Internally the dose is one-fifth grain; it is also used by hypodermic injection, in one-tenth to one-half-per-cent. solution, and the same solution is used for washing out the bladder, the urethra, and other sensitive mucous membranes. For irrigating wounds, a one- to five-per-cent. solution, either alone or with glycerin, may be employed; for putrid surfaces, a five- to twenty-per-cent. solution in equal parts of water, glycerin, and alcohol. Gauze may also be prepared by medicating with the solution. In eye affections, a one to five thousand solution is used as an ordinary antiseptic wash.

Beaumont Small.

IODIPIN is an addition product of sesame oil and iodine, and appears in two strengths of the latter, viz., ten and twenty-five per cent. It is yellowish with a bland oily taste, the stronger compound being for hypodermic use only. Frieser considers it superior to the iodides, as it is quickly absorbed and slowly excreted, yet does not produce iodism or gastric disturbances. If objection is made to the oily taste it may be given in emulsion, or by rectum or subcutaneously. Its ordinary dose is one teaspoonful. It does not set free its iodine in the stomach, therefore saves this organ from the irritation of free iodine. It is, however, split up and quickly absorbed in the intestines. Sternberg finds the iodine reaction in the saliva in sixty-five minutes after ingestion by persons with normal stomachs; he therefore uses iodipin as a test for the motor function of the stomach. A delay in the reaction would indicate that the motility of the stomach is impaired.

G. Nobl used iodipin by injection in twenty cases of tertiary syphilis with excellent results. Even three ounces (90 c.c.) of the twenty-five-per-cent. compound injected within a short time gave no symptoms of iodism.

W. A. Bastedo.

IODISM.—This term has been applied to intoxication brought about by the persistent use of iodine in any form. As a rule the name is not given to acute poisoning, though occasionally latitude is exercised in this direction; as, for example, when iodine poisoning results from external applications such as iodoform which causes a poisoning by decomposition and absorption of the contained iodine.

When acute symptoms of poisoning result from the presence of iodine in the gastro-intestinal tract, the term iodism is less appropriate.

The usual mode of intoxication is through the continued use of some iodine compound like potassium or sodium iodide. Occasionally the internal or even local use of iodine itself has been the cause of the poisoning. As has been pointed out above, the decomposition of iodoform with consequent absorption of iodine sometimes occasions general as well as local symptoms.

The amount of iodine necessary to produce symptoms of poisoning varies in individual cases according to personal peculiarities, the pre-existence of certain diseases, and the manner of administration of the drug itself. By gradually increasing the dose of the drug, considerable quantities of an iodide or of iodine may be tolerated by normal persons, and the tolerance of syphilitics for this drug is so well known that many clinicians believe the therapeutic test of administering iodides to ascertain the patient's tolerance is of value in the diagnosis of a syphilitic taint. It is claimed by those who advocate the value of the therapeutic test that the tolerance of large doses without the development of symptoms of iodism is an evidence of syphilis; and, on the other hand, the development of symptoms is an evidence of freedom from that disease. There is no doubt but that those who have been infected with this disease often bear very large doses of iodide in most instances, but the value of the test is frequently exaggerated. It has decided limitations. The same tolerance seems to occur in persons affected with actinomycosis, against which disease iodine and the iodides appear to be almost specific. Sometimes it is noted that small doses of an iodide provoke symptoms of intoxication after the lapse of some days and that these milder symptoms subside when the drug is pushed and larger doses are given. The severer symptoms are rarely met with excepting after more prolonged use of the drug and its administration in comparatively large doses. In a case reported by Robinson the patient suffered with mild symptoms after six doses of one grain each of iodide of potassium, and a few days later, the same doses being continued, purpura developed. In another case reported by Fox, violent symptoms appeared after the administration of ten grains of potassium iodide. On the whole, however, the statement made above that severe symptoms rarely develop until larger amounts of the drug have been ingested is borne out by experience.

In acute poisoning by iodine, symptoms indicative of a violent toxic gastro-enteritis are met with. Among the peculiar accompanying symptoms are a metallic taste in the mouth and an increased flow of saliva, rapidity of the pulse out of proportion to the gastro-enteric disease, and partial or complete suppression of urine. In chronic poisoning or iodism there may be some of these symptoms in milder form. A peculiar metallic taste in the mouth, slight swelling and redness of the gums, and later a well-marked gingivitis, increased flow of saliva and disturbances of the stomach and bowels are met with. On examination of the mouth there may be found a brilliant red line on the gums at their junction with the teeth, or, in later stages, a necrotic or ulcerated appearance of the gums. The breath in these cases is apt to be heavy, though not nearly so offensive as in mercurialization. Slight swelling of the parotid gland and less frequently of the other salivary glands and of the submaxillary lymphatic glands may be met with. Coryza and irritation of the eyes are frequent early symptoms and an acneiform eruption of the skin is quite characteristic. This acne generally presents a more inflammatory appearance than ordinary acne and is in my experience apt to occur in a clustered form, several spots being closely grouped together. This arrangement, however, is by no means invariable. The eruption comes on gradually or, less frequently, abruptly. It may persist for some time without other symptoms of iodism, but as a rule soon ushers in more serious symptoms. Later, pharyngitis and bronchial irritation and various forms of eruptions on the skin occur. Among the last named, vesicles, bullæ, and purpuric spots are of most interest. In many cases reported in the literature a well-marked purpura hæmorrhagica occurred. Sometimes this developed after small doses of iodine; in most cases, however, the amount ingested was considerable. The petechiæ generally occur on the lower extremities first, but later involve all parts of the body; and hemorrhages from the mouth, nose, stomach, or other mucous membranes frequently accompany the eruption. The hemorrhagic eruption may consist of merely small petechiæ or may in other cases take the form of hemorrhagic vesicles or considerable suffusions. Sometimes the lesions are confined to the parts of the extremities near the joints and may, as in a case re-

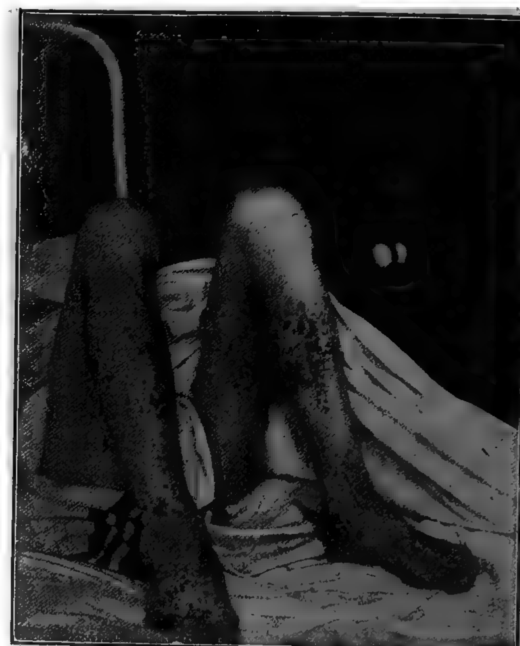

FIG. 2951.—Iodic Purpura Simulating Purpura Rheumatica. (Stengel, in *Therapeutic Gazette*, 1902.)

ported by myself, be attended with swelling of the joints, giving the whole case the appearance of the disease known as purpura rheumatica. In these cases pain in the extremities may occur, but as a rule the eruption of iodism is entirely painless and free from all other sensations.

In some instances there is a special tendency to this form of iodism, and cases have been reported of patients who repeatedly suffered symptoms of this kind on every attempt to renew the administration of iodides. Occasionally iodism is attended with fever; in most cases this symptom appears to be wanting.

Nervous and vascular symptoms sometimes predominate; thus headaches and neuralgic pains, tremor or twitchings of the muscles, and a state of profound asthenia may be met with. It is reported also that loss of vision and paralysis occur in some cases. A peculiar syndrome has been discussed by recent authors as being the occasional result of medication with iodine; it suggests the symptoms of exophthalmic goitre.

In these cases the patient has great rapidity of the heart's action with a sense of intense palpitation. There are muscular tremor, more or less pronounced dyspnœa, and a relaxed condition of the skin, and sometimes the clinical picture is completed by the development of exophthalmos. These cases are especially interesting from the fact that according to many, Graves' disease is due to excessive thyroidal secretion, and the latter is known to contain notable proportions of iodine.

In cases of iodism following the local use of iodoform, in addition to a dermatitis, there are marked rapidity and

weakness of the heart's action and great constitutional depression. The temperature is sometimes quite high. When the erythema or dermatitis is extensive, there may be difficulty in distinguishing the symptoms from those of scarlet fever, particularly if, as sometimes happens, vomiting and gastro-intestinal symptoms mark the beginning of the attack. In certain cases when the poisoning has developed slowly, the disease takes on a cachectic form and is marked by gradual wasting with loss of subcutaneous fat causing a wrinkled, withered appearance of the skin. Combined with this there are great muscular weakness and nervous depression, a tendency to dyspnœa, and rapidity of action of the heart. The appearance of the patients suggests a profound anæmia or cachexia.

Among late results of iodine intoxication, atrophy of the mammary glands and testicles has been noted.

Alfred Stengel.

IODOFORM.—Iodoform, chemically *triiodomethane*, or *methenyl iodide*, CHI_3, is official in the United States Pharmacopœa as *Iodoformum*, Iodoform. It is prepared in a variety of ways, in which the essential reaction is between alcohol and free iodine with the resulting formation of iodoform. Iodoform occurs in "small, lemon-yellow, lustrous crystals of the hexagonal system, having a peculiar, very penetrating, and persistent odor, somewhat resembling that of saffron and iodine, and an unpleasant, slightly sweetish, and iodine-like taste. Specific gravity, 2.000 at 15° C. (59° F.). Very slightly soluble in water, to which it, however, imparts its odor and taste. Soluble in about 52 parts of alcohol at 15° C. (59° F.), in about 12 parts of boiling alcohol, and in 5.2 parts of ether. Very soluble in chloroform, benzin, and fixed and volatile oils" (U. S. P.). Iodoform volatilizes somewhat even at ordinary temperatures, and on heating first melts to a brown liquid, and then gives off iodine vapors, with a residual carbonaceous mass, which finally is wholly dissipated. Iodoform should be kept in well-stoppered bottles in a cool place. The *odor* is peculiar not only in quality, but also in the fact that it is very penetrating and persistent, and that a very little of the substance will develop the smell in full strength. To many persons the odor is positively offensive, while to others it is quite unobjectionable. Concerning the solubilities of iodoform, it should be noted that a very common text-book error is the unqualified statement that the substance is "soluble in alcohol," leading to the inference that it is freely so, whereas, as a matter of fact, it is but sparingly soluble in cold, and only moderately soluble in boiling, alcohol (see above).

Locally, iodoform tends to benumb, to repress suppuration and other unhealthy action, and to promote healing. In tuberculous disease, as in cases of tuberculous abscess, the latter effect is marked. This healing virtue of iodoform probably results partly from absorption by the powder of the juices of the exposed part, and from mechanical protection, and partly from the action of free iodine liberated through decomposition of the iodoform. Such decomposition readily occurs when iodoform meets with alkaloidal or albuminous fluids. Formerly the virtues were thought to be due to a germicidal action, but it is now shown that iodoform as such has little or no direct power either to kill pathogenic micro-organisms or to hinder their development.

Iodoform can be absorbed into the system, not very readily from the stomach, but quite so from fresh wound surfaces, and in such cases a certain amount, at least, enters the blood unchanged. It is excreted mainly by the kidneys and in the form of iodides, but also is to be found in the saliva, the bronchial mucus, and the perspiration. Swallowed in quantities of from 0.30 to 0.40 gm. (gr. v. or vi.), it is harmless, but when extensively applied to absorbent wound surfaces it is capable of producing serious and even fatal constitutional poisoning (see *Iodoform. [Toxicological.]*).

Iodoform has been tried as an internal medicine in the place of the alkaline iodides, especially in syphilis, but without striking results. The dose is from 0.06 to 0.20 gm. (gr. i. to iij.) three times a day, preferably in pill, in order that the odor may be concealed. Externally, iodoform is a good anodyne application to painful surface affections of all kinds, and is specifically healing, especially in syphilitic lesions and in local tuberculous affections. Also it makes an excellent dressing for wound surfaces, and is accordingly extensively used by the operating surgeon. It may be applied dry (finely pulverized, so as to obviate the mechanical irritation by the edges of the crystals), by dusting from a dredger, and then covering the dressed surface with cheese-cloth, lint, or absorbent cotton; or an iodoformized gauze may be used. Such gauze may be prepared by rubbing powdered iodoform into the meshes of the material, or the latter may be soaked in an ethereal solution of iodoform which, by drying, leaves a fine powder of the drug evenly diffused through the texture of the fabric. Care should be taken not to risk poisoning by packing considerable quantities in tightly closed wound or abscess cavities. As a healing dressing, the official preparation may be used, entitled *Unguentum Iodoformi*, Iodoform Ointment, which consists of iodoform, ten per cent., thoroughly incorporated with benzoinated lard. In the local treatment of tuberculous abscesses a ten-per-cent. emulsion in sterilized oil or in glycerin has been much used. The abscess is first properly evacuated, then cleansed by a weak carbolic or boric-acid wash, and then injected with a few fluid-drachms of the iodoform emulsion, and the cavity closed. Such treatment may be repeated every few days. These same emulsions have also been injected into the substance of tuberculous glands which have not undergone suppuration. To mask the diffusive and persistent *smell* of iodoform, the addition of a great many substances has been proposed, of which substances some, such as the Tonka bean and the more powerfully odorous of the volatile oils, simply overwhelm the smell of iodoform with their own odor, and are hence unobjectionable. A bit of Tonka bean may be kept in the iodoform bottle, or one part of oil of bergamot, peppermint, spearmint, or gaultheria may be added to twenty parts of iodoform (Hager). Tannic acid and balsam of tolu, two substances suggested for the present purpose, act by chemical attack upon the iodoform, and hence are not to be recommended.

Because of the offensive smell of iodoform and the occasional poisoning by the medicine, many substitutes have been sought in related compounds. Of these the following deserve mention:

Iodol, tetraidopyrrol, C_4I_4NH. This compound forms by the action of iodine on pyrrol, and occurs as a yellowish-brown, crystalline powder, without taste or smell, insoluble in water, but soluble in alcohol and, though less readily, in ether, chloroform, and the fixed oils. It contains 88.9 per cent. of iodine.

Iodol, though insoluble in water, is capable of absorption by the living animal tissues, and so produces constitutional effects on administration by the mouth. In experiments on animals it has caused emaciation and albuminuria, with muscular weakness and lowering of temperature, and, finally, death from fatty degeneration of the kidneys and liver. Constitutional effects have followed also the local use of the compound in surgery, but, owing to the comparative slowness of absorption of iodol, it is less apt to produce untoward effects than is the case with iodoform.

Iodol is available for all the uses of iodoform. It may be applied locally in powder or in alcoholic solution. A collodion preparation of iodol may be made by dissolving one part of iodol and five of guncotton in ten parts of ether.

Iodol has been given internally in diabetes and in tertiary syphilis, in doses of from 0.13 to 0.19 gm. (gr. ij.–iij.). It is not official in the United States Pharmacopœia (1890).

Losophan, triiodometacresol, $C_6HI_3(OH)(CH_3)$. This substance, a compound of iodine and cresol, occurs in colorless needles, odorless, insoluble in water and nearly so in alcohol, but freely soluble in ether, chloroform, and

the fixed oils. The crystals contain 78.39 parts of iodine and melt at 121.5° C. (250.5° F.).

Unlike iodoform, losophan does not yield free iodine on contact with the animal tissues, and so cannot truly substitute iodoform in medical practice. It has been used as a local antiseptic, but with questionable advantage. It may be applied in a one- or two-per-cent. solution in alcohol and water (alcohol three parts, water one part), or in an ointment of from one- to ten-per-cent. strength, with basis of vaseline or a mixture of vaseline one part, and lanolin four parts.

Losophan is not official.

Nosophen, tetraiodophenolphthalein, $(C_6H_2I_2.OH)_2.C<^{C_6H_4CO.}_{O}$ This compound, behaving as an acid, occurs as an impalpable, pale yellowish powder, odorless and tasteless, insoluble in water and difficultly so in alcohol, ether, and chloroform, but soluble in alkalies, with which substances it combines to form salts. Nosophen contains 61.7 per cent. of iodine.

Like losophan, nosophen does not yield iodine on contact with the animal tissues. It has been used, however, for the purposes of iodoform, and is unirritating and non-poisonous. It may be applied freely in its powder form.

The sodium salt of nosophen has been used in medicine under the name of *antinosine.* This salt occurs as a dark blue amorphous powder, and is freely soluble in both water and alcohol. It may be used for local antiseptic purposes in solutions varying in strength from one to three per cent., which solutions are without odor or taste.

The bismuth salt also has been used under the name of *eudoxine.* This substance is a reddish-yellow powder, tasteless and odorless, and insoluble in water. It is decomposed by alkalies with the formation of antinosine. It has been given internally, for gastro-intestinal derangements, in doses of from 0.03 to 0.50 gm. (gr. ss.–viij.), and is assumed to undergo conversion into antinosine by the action of the alkalies in the intestinal fluids.

Nosophen is not official.

For *europhen*, see article under its own title.

Edward Curtis.

IODOFORM. (TOXICOLOGICAL.)—In 1880 Mosetig von Moorhof introduced iodoform as a surgical dressing. Since that time it has been largely used by surgeons not only as a dressing, but also (in solution) for injection into chronic abscesses, tuberculous joints, etc. In many cases grave symptoms have supervened; sometimes followed by recovery, occasionally by death. Such cases have been steadily reported since 1882, but now there seems to be a lull, probably owing to the fact that iodoform is not in such general use as formerly.

Cases have been reported of which we may mention: (1) A series of four, all of which ended in recovery, described by Marcus Beck, of London (*Brit. Med. Journal*, 1882, i., p. 903). (2) Barois (*Archiv. de Méd. et de Pharm. Milit.*, 1890) has collected a series of forty-two fatal cases, and adds one of his own; the remarkable point in this series is that there is only one case of an American surgeon, viz., that of Dr. Sands, in 1881, in which about one and a half drachms were used in dressing after colotomy for cancer of the rectum. (3) Andry's series of four (*Lyon Médical*, 1890), one of which proved fatal. (4) Gerlach's series of four cases, all of which terminated in recovery (*Medical News*, Philadelphia, 1891, p. 273).

Iodoform is generally applied either (1) pure, as a powder, (2) combined with collodion, (3) dissolved in ether, (4) incorporated with gauze, or (5) as an emulsion in glycerin or oil. Of these the iodoform gauze is probably the safest. An alkali added to the iodoform is said to render it less toxic. When iodoform is used, mercurials and carbolic acid should be avoided. Iodoform is quickly absorbed and slowly eliminated; clean, granulating wounds, large surfaces, fatty tissues, burns, sinuses, fistulæ, and abscess cavities are particularly favorable for the absorption of iodoform.

Toxic Dose.—The smallest dose known to have produced *toxic* symptoms is less than one grain. This was a case reported by Dr. Tiffany, of Kansas City (*St. Louis Med. and Surg. Journ.*, xxxviii., 562), in which a fraction of a grain of iodoform was applied to the tympanum through the external auditory meatus. The patient, a woman, who had an idiosyncrasy to the drug, suffered from inflammation, swelling, and erysipelas; recovery followed on withdrawal of the drug. The smallest *fatal* dose is probably about forty-five grains. The case, which is reported by Barois (see above), was one of large cold abscess under the left pectoralis major; an injection of about fifty-five grams of a five-per-cent. ethereal solution was used; symptoms of ether narcosis immediately followed, then symptoms of iodoform poisoning, chiefly cerebral, and death in coma after nine days. Fatal results from doses of one drachm and upward have been reported. But, on the other hand, a case has been recorded in which a woman took two drachms of iodoform at a single dose, with no worse result than severe headache, griping pains in the abdomen, and purging; but the odor and taste of the drug remained for several days.

It must be borne in mind (1) that many toxic effects may have been due to impurities in the drug; (2) that some people are particularly susceptible to iodoform, and many cases of iodoform poisoning are due to idiosyncrasy; (3) that iodoform seems particularly dangerous in wounds and injuries of the breast, axillary space, and chest wall, and therefore great care should be taken in using the drug in these regions.

Symptoms.—The cause of the toxic symptoms is the iodine. Iodoform (CHI_3), which contains more than ninety-six and one-half per cent. of iodine, is decomposed by the tissues with which it comes in contact, and iodine is liberated. This free iodine promptly combines with the albumin of the tissues, and the result is an unstable albuminate of iodine, which passes into the circulation and thence to the various organs of the body.

Schede, of Hamburg, describes six classes of cases of poisoning by iodoform: "(1) High fever without other phenomena. (2) Fever, with mild gastro-intestinal irritation, depression of spirits, and rapid pulse; recovery almost invariable. (3) Very rapid, soft pulse, from 150 to 180; no fever; great danger. (4) Very rapid pulse with high fever; death almost invariable. (5) After severe operations, rapid collapse and death. (6) A form resembling meningitis, somnolence followed by stupor; contracted, motionless pupils; restlessness, temperature normal, and pulse exceedingly rapid; most characteristic and severe" (from H. C. Wood's "Therapeutics").

We prefer a simpler classification: 1. Local or cutaneous or eruptive. 2. General or constitutional: (*a*) with cerebral symptoms; (*b*) with coma.

1. *Local, Cutaneous, or Eruptive.*—This is the commonest form and generally follows the application of iodoform as a dressing. There is a dermatitis of an erythematous type, or an eczematous eruption. The part is swollen and is covered by many small thick-walled vesicles. These vesicles become confluent and are filled with a serous fluid which may later become tinged with blood. The epidermis is at first raised; later it peels off, and leaves an exposed area of very sensitive corium bathed in a serous exudate.

2. *General or Constitutional (a) with Cerebral Symptoms.*—This may occur some time after the application or injection of the iodoform, or almost immediately. The symptoms are the odor of iodoform in the breath; yellow discoloration of the skin and conjunctivæ; increase of temperature; pulse small, irregular, and rapid (up to 160 or 180); faintness, vertigo, severe headache, thirst, nausea, vomiting, gastro-intestinal irritation, muscular twitchings; the patient becomes melancholic and has delusions of persecution and possibly suicidal tendencies, hence must be carefully watched; there is maniacal excitement, which may subside on removal of the dressing. "There is nothing specific in iodoform mania; it may occur with the first dressing, or it may result from its prolonged use; it gives rise to restlessness, to sleeplessness, to irritability passing into mania, and the mania

may rapidly give place to stupor or mental weakness" (Dr. Savage, in Allbutt's "System of Medicine," vol. viii., 315). Barois found in severe cases that the symptoms came on suddenly and early; first mental depression, then excitement.

(*b*) *With Coma.*—This is the most severe form. The pulse is rapid and feeble; there is rigidity of the neck, as in meningitis; great mental confusion with misplacing of words; there may be paralysis of the sphincters; the patient becomes emaciated, lethargic, and falls into a state of coma and dies.

Death occurs from paralysis of the heart. Age increases the susceptibility of most persons to the action of the drug. Tuberculous and cachectic patients are said to give worse results than others: but probably iodoform is more often administered to these patients than to others.

PATHOLOGY.—The post-mortem findings are fatty degeneration of the heart, liver, kidneys, and muscles; hyperæmia of the meninges and some atheromatous lesions of the arteries. Barois found occasionally a partial infiltration of the lungs, with degeneration of the alveolar epithelium.

PROGNOSIS.—This is bad. It probably depends upon idiosyncrasy as well as dose.

PROPHYLAXIS.—Get a pure preparation of the drug; use as small an amount as possible; remember idiosyncrasy; be particularly cautious in wounds of the breast, chest walls, and axillary space.

TREATMENT.—In every case stop the application of further iodoform; then keep up the patient's strength and remove as much as possible of the drug with water, a warm solution of starch, oil of eucalyptus, or ether and cotton; and give diuretics, diaphoretics, and a hot bath to hasten elimination. In a case reported by Dreesmann, of Bonn (*Beitr. zur klin. Chir.*, v., 9, p. 233), hypodermic injections of twenty-per-cent. solution of iodoform oil were repeatedly given for white swelling of the knee; neurotic symptoms followed, and on resection of the knee a mass of iodoform the size of a cherry was found just above the condyles; the neurosis ceased on the removal of this. Apply dressings of decinormal salt solution, snip off the top of any vesicles that may be present, so that the solution may reach the corium underneath; locally apply some non-irritating alkaline fluid to neutralize the nascent iodine, and thus prevent its entering into combination with the albumins. Give stimulants, and to increase the alkalinity of the blood administer potassium acetate, potassium bicarbonate, or potassium bromide; this latter is recommended, and may be administered in an initial dose of gr. xv. in ℥ ij. of water, followed by gr. x. every hour. *R. J. E. Scott.*

IODOGALLICIN is an iodine compound of gallicin (see *Gallicin*), and is a gray amorphous powder which is insoluble in all ordinary media. It contains 38 per cent. of bismuth and 23.6 per cent. of iodine. It is antiseptic, locally anæsthetic, and desiccating, and may be applied in powder or in five-per-cent. lanolin ointment for wounds, ulcers, trachoma, and corneal ulcers. *W. A. Bastedo.*

IODOL.—Tetra-iodo-pyrrol, C_4I_4NH. This compound of iodine may be prepared by dissolving pyrrol in alkaline water and mixing it with a solution of iodine in iodide of potassium. The precipitate is collected, dissolved in alcohol, and reprecipitated. It is also obtained by the reaction that takes place when alcoholic solutions of pyrrol and iodine are mixed for twenty-four hours. Iodol separates when the mixture is added to water.

It is a pale yellow, finely crystalline powder. It is without taste and does not possess any disagreeable odor. It is insoluble in water, and very slightly soluble in dilute alcohol. Strong alcohol dissolves one part in six; glycerin, one part in thirty-four. Iodol is very soluble in ether and chloroform. It contains about ninety per cent. of iodine. Heated to 140° or 150° C. it is decomposed with the evolution of violet iodine vapors.

Iodol was introduced in 1885 by Ciamician and Silber, as a substitute for iodoform, its freedom from any disagreeable odor being a decided advantage. Like iodoform it does not rank high as a germicide, but it has the same power of inhibiting the growth of bacteria and maintaining a surface clean and aseptic. To wounds, ulcers, and all suppurating surfaces it is applied in the same manner as iodoform, by dusting the powder on the part or making it into an ointment with lanolin or vaselin. It may also be used in solution of alcohol, ether, or collodion. Ether 5 parts, collodion 50 parts, iodol 1 part is a favorite combination for local application. For gynæcological purposes a solution of iodol, spirits, and glycerin, 1 to 16–34, may be used for saturating tampons, etc. Its local use has been highly recommended for ulcerations of the nose, pharynx, and larynx, particularly when due to a tuberculous or syphilitic cause.

Iodol has been employed internally with success in conditions of the stomach and intestines accompanied by putrefactive and fermentative changes. It has been used with success in gastro-intestinal catarrh and ulceration of the mucous membrane. When its action is directed to the stomach it should be given in the intervals between meals; when it is desired to act on the intestinal canal, the most favorable time for its administration is immediately at the close of the digestive process. As its constituent iodine is excreted in part by the pulmonary organs, it has been used in bronchitis, phthisis, and various diseases of this locality. In these conditions, in addition to its internal administration, inhalations and insufflations have been used. In syphilis it is also recommended, especially in tertiary forms of the disease in which it has given the best results. It is well borne by the system, having no effect on the temperature, circulation, or respiration; iodism is of very rare occurrence. It is also thought to be of benefit in diabetes. The dose is from one to three grains, two or three times a day; it should be given in wafers or pill form. *Beaumont Small.*

IODOMUTH ($Bi_4C_7H_7I_2O_5$) is a bismuth iodine compound, used as a dusting powder for wounds, ulcers, etc. It has been given internally as an alterative in dose of gm. 0.06–0.6 (gr. $\frac{1}{10}$–i.). *W. A. Bastedo.*

IODONAFTAN is a naphtha ointment base containing three per cent. of iodine. It is a very smooth, stable ointment of pleasant odor. It is blackish-brown in color, appearing dark green by transmitted light. *W. A. Bastedo.*

IODONAPHTOL-BETA. — Naphtol-beta di-iodide. Also termed Naphtol-aristol. This derivative of iodine was introduced by Dr. Braille (*Répert. de Phar.*, November 10th, 1891) as a substitute for iodoform, aristol, and other iodine compounds. It is prepared by mixing a solution containing 24 gm. of iodine and 27 gm. of potassium iodide with another solution containing 110 gm. of naphtol-beta and 40 gm. of caustic soda. There is then added a little solution of the hypochlorite of sodium corresponding to ten times its volume of chlorine. Iodonaphtol is then precipitated. It is a greenish-yellow powder, inodorous, tasteless, insoluble in water, very slightly soluble in alcohol, but soluble in ether and chloroform.

It is recommended for the treatment of wounds, ulcers, and all conditions in which iodoform and other antiseptics are employed. It is applied as a powder dusted on the part affected. *Beaumont Small.*

IODOPHENIN.—Iodophenacetin. This compound of iodine and phenacetin was described by Dr. Scholvein, in 1891, at a meeting of the Berlin Pharmaceutical Society. It contains fifty per cent. of iodine and forms in steel-blue crystals, with an odor of iodine, and a burning taste; it colors the skin yellow. It is insoluble in water, soluble in alcohol and glacial acetic acid. Heated, or even when mixed with water, it is decomposed and iodine is set free.

It is recommended as a useful antiseptic, and experi-

ments show that it possesses this property in a marked degree, but it also has the irritating effects of free iodine.

When employed as an internal remedy it forms combinations with the alkalies of the intestinal canal, and, from the readiness with which iodine is given up, poisonous symptoms may follow the use of even small quantities. *Beaumont Small.*

IODO-SALICYLIC ACID.—A compound of iodine and salicylic acid in which one atom of hydrogen is replaced by one of iodine. It contains fifty per cent. of iodine. A *di-iodo-salicylic acid* is also prepared, in which two atoms of hydrogen are replaced by iodine. It contains two parts of iodine in three of the compound. They are white, fine, crystalline powders, slightly soluble in water, soluble in alcohol, ether, fixed oils, and collodion.

They possess the combined action of iodine and salicylic acid, and are said to be very serviceable antiseptics. Internally, in doses of from twenty to sixty grains daily, they have proved serviceable in rheumatism and have succeeded in relieving the fever and pain when the other salicylates have failed.

Sodium di-iodo-salicylate.—This salt occurs in white needles, and is recommended as an antithermic and antirheumatic. It is also said to be of great value as a local application in parasitic affections of the skin. The dose for internal administration has not been determined. *Beaumont Small.*

IODOSULPHATE OF CINCHONINE.—(Synonym: Antiseptol.) This compound contains fifty per cent. of iodine. It is a very light, brownish powder, odorless, insoluble in water, alcohol, and chloroform.

It is an antiseptic and is said to prove serviceable in all conditions in which iodoform and similar compounds are employed. It may be combined with powdered talcum, one part to two; or mixed with vaselin or lanolin, one part to ten. *Beaumont Small.*

IODOZEN ($C_6H_2I.COOCH_3ONa$) is an iodine derivative of methyl salicylate. It is used as an antiseptic externally and as an alterative internally. *W. A. Bastedo.*

IPECAC.—IPECACUANHA.—The dried root of *Cephaëlis Ipecacuanha* (Brot.), A. Richard. [*Uragoga Ipecacuanha* (Brotero) Baillon (fam. *Rubiaceæ*).] U. S. P. It is doubtful if this definition, for reasons given below, should not be made to include the lower or prostrate portions of the stem also. The name of this drug, which is adopted into most European languages, is borrowed from the South American Indians, by whom it is used to designate, not only this, but several other emetic roots. *Poaya* is another Bazilian name, also rather loosely applied to other roots besides the one under consideration. "Ipecac" is a natural and convenient abbreviation.

The plant from which this drug is obtained is a low, semi-gregarious shrub, growing in the deep tropical woods of Brazil, with partly creeping stems and thickened annulated roots.

The roots, several in number, are long, tortuous, simple or slightly branching, white and filiform when young, but at maturity thickened to three or four times the diameter of their woody columns by the accumulation of starch-bearing tisue in the bark. This occurs in crowded, narrow, irregular, and generally incomplete, transverse rings, separated by deep, also incomplete, circular fissures, and is greatest in the middle portion of the root, which tapers toward each end, especially the lower. The woody column does not take part in either the rings or furrows of the bark. The stems of *Cephaëlis* are of soft woody, sometimes almost herbaceous, texture; rounded, smooth, creeping, and rooting below; ascending, square, pubescent, and green above, with well-marked nodes and leaf scars. It is this lower, rounded portion, lying shaded and for the most part covered by forest débris, which has practically the same composition and properties as the root, and which might be, and commonly is, used with it. The remaining portions of the plant are well illustrated in the accompanying cut, which, however, does not show the prostrate habit of the basal portion of the stem.

HABITAT.—The district of Matto Grosso, in western Brazil, is the principal source of ipecac; but the plant grows also in the adjoining parts of that country as well as of Bolivia. The ipecac plant has been long cultivated as an object of interest in botanical gardens, especially in that at Edinburgh. Mr. McNab made the important discovery that it could be propagated by minute fragments of its roots, or even of its leaf stalks. By means of this plan a large number of plants has been obtained and sent to India and elsewhere for experiments in regard to its practical cultivation; so far, however, because of the slowness of its growth and the smallness and consequent expensiveness of the yield, its culture has not been commercially successful, and we are still obliged to rely upon its native country for our supply. It is collected by the Indians in Brazil throughout the year, but mostly during the wet season, when the ground is soft, by simply grasping the stems in one hand and prying out the roots with a pointed stick held in the other. The gravel is then shaken out and the roots are dried in the air. When dry, they are sifted and sorted and packed in serons (bales made of hide) for transportation. It is mostly bought up by travelling traders, and suffers much exposure during their journeys, so that much of it reaches us in a mouldy and damaged condition. Ten or twelve pounds per day is said to be a good average collection. Ipecac collection is exceedingly irritating to the hands, especially the finger ends, as well as to other parts of the body, and is hence very objectionable to the laborers.

FIG. 2952.—Ipecac Plant. (Reduced about one-third.) (Baillon.)

The modern high price for rubber having afforded a profitable opening, its collection is preferred, and the price of ipecac has on this account very greatly advanced.

HISTORY.—The following paragraph is condensed from Flückiger and Hanbury. A doubtful reference to ipecac is made in an old treatise upon Brazil, published by Purchas in 1625. Piso and Marcgraf (1648) described it, and

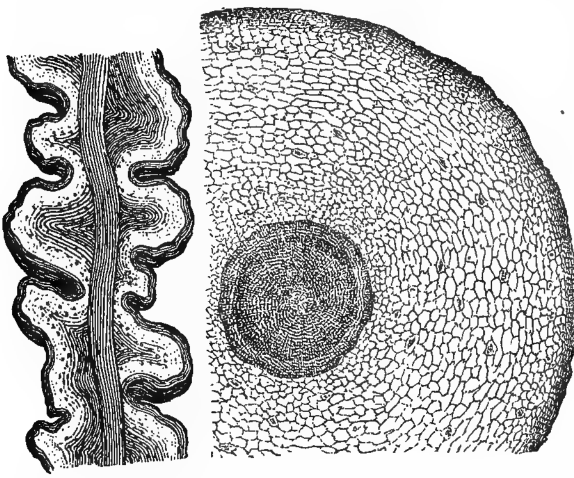

FIG. 2953.—Longitudinal and Transverse Sections of Ipecac Root.

stated that it was in common use in Brazil. It was first carried to Europe in 1672, and its usefulness established by Helvetius about 1686, who kept its identity a profound secret until he received from Louis XIV. a handsome price for publishing it to the world in 1688. This early use of ipecac was not as an emetic, but in the treatment of dysentery, which is still its principal employment in tropical countries.

OFFICIAL DESCRIPTION.—In pieces of indefinite length, rarely exceeding 15 cm. (6 in.), and 3 to 6 mm. ($\frac{1}{8}$ to $\frac{1}{4}$ in.) thick, curved and sharply tortuous, almost free from rootlets; surface red-brown or brown, occasionally blackish-brown, rarely gray-brown, closely annulated and usually exhibiting transverse fissures through the bark, their sides vertical; fracture short, the very thick, easily separable bark grayish, usually resinous, the thin wood yellowish-white, without vessels; odor very slight, peculiar; taste bitter and nauseous, somewhat acrid.

When very thick, of a dull-gray color, with thin, merging annulate and with many starch grains exceeding 12 or 14 μ it is from *Cephaëlis acuminata* Karst., and should be rejected.

When ipecac is sound and free from mouldiness, its quality is proportionate to the thickness of the bark and the thinness of the ligneous portion.

The bark of ipecac consists entirely of thin-walled, polyhedral cells scarcely longer than broad, and pretty well filled with clustered and faceted starch grains, solitary grains rarely reaching a diameter of 12 or 14 μ. Liber wanting. All the medicinal activity of the drug resides in the bark, the wood being worthless and nearly tasteless.

ADULTERANTS AND SUBSTITUTES.—The adulterants of and substitutes for ipecac have been so numerous and important that works have been written upon the subject. All have now practically disappeared, so far as the American market is concerned, with the exception of *Carthagena Ipecac*, the root of *Cephaëlis acuminata* Karsten, of Colombia. This root is collected and sold, under the name of ipecac, upon a scale almost as extensive as that of the genuine drug. Although supposed to be excluded by the United States customs laws, it does enter to a very considerable extent. In its ordinary form, it is readily distinguished, being a half or more larger, of a dull brownish-gray color, less strongly annulated, and especially less deeply constricted between the annulations. The writer has seen the process in operation, in London, of selecting the pieces in which these distinctions are the least marked, and staining them for the American market. The fractured surface is less distinctly white, being rather of a horn-grayish white, and the powder shows a similar difference. In the latter, the starch grains reach a much greater size and are more inclined to be solitary. It is very questionable if this root is inferior to the genuine, or if it should not be admitted to the Pharmacopœia. Its percentage of total alkaloid is commonly a little greater than in the genuine; but the composition of this alkaloid, or rather its physiological and therapeutical action, is so uncertain that it has been refused admission to the recent edition of the British Pharmacopœia.

COMPOSITION.—The medicinally unimportant constituents of ipecac are a large amount of starch and calcium oxalate, and small amounts of pectin, sugar, and resin. The important constituents are *ipecacuanhic acid* and the alkaloids, namely, *caphaëline*, *emetine*, and a third not yet studied, the three alkaloids together existing to the extent of about two per cent. Of this total, the emetine constitutes about three-fourths, the cephaëline about one-fourth, the third being in very small amount. In Carthagena ipecac, the cephaëline is about three-fifths, the emetine about two-fifths. The physiological and therapeutical importance of the ipecacuanhic acid and of the third alkaloid is not known, but there are special reasons why it is in great need of investigation, especially that of the former substance. There is nothing in the action of either emetine or cephaëline to explain the repute of ipecac in the treatment of dysentery, a repute so strong and general as to demand recognition. This effect appears to be secured, moreover, after the removal of the alkaloids, and it would appear that it must be due to the bitter acid, which is in reality a glucoside.

Cephaëline ($C_{14}H_{19}NO_2$) is separated from *Emetine* ($C_{14}H_{18}(CH_3)NO_2$) by the use of an aqueous solution of caustic alkali, the emetine being taken up from it by ether.

ACTION.—Ipecac (and still more the alkaloid) is a moderate local irritant, producing smarting, redness, and, if a long-continued application is made to the skin, finally troublesome pustulation. The powder of either, inhaled, produces sneezing, stinging, and increased secretion from the nostrils and deeper air passages; in susceptible persons a severe coryza may be simulated. In experiments upon animals, diarrhœa and even dysentery, with bloody discharges and inflamed intestinal mucous membranes, have followed large doses. It is thus evident that local stimulation, or irritation at least, forms a very characteristic part of the action of ipecac. This is also seen in the pain and inflammation, frequently abscess, at the point of hypodermic injection, on account of which this mode of use is not available. As to the systemic effects when thus introduced into the circulation, it is to be noted that in fatal cases severe inflammation of the lining of the stomach and intestine has frequently been observed, all the indications being that it has resulted from excretion of the alkaloids into these organs. Irritation of the pulmonary tissue, which is often severe, is apparently due to a similar excretion there. The emetic action of the drug, as well as the salivation and nasal discharge, could thus be readily explained on the ground of local irritation. When the alkaloid is taken, it is distinctly noted that there are two periods of gastric disturbance, one following the other at an interval of about thirty minutes. It has been thought that this second attack was due to central action, after the alkaloid had become absorbed; but it is at least possible that it follows its re-entrance into the stomach upon excretion from the circulation. Whether the emesis of ipecac is purely a local effect or partly of central origin, is the most important question concerning it. It is notable that the disturbance of emetine is less than that of cephaëline, of which latter emetine is a methyl compound; and we know that methyl compounds are often less energetic irritants, or are even sedatives, to the centres. This would seem to indicate central activity. This question is not of practical importance, as the general effects of the drug are clear and evident. When taken

into the stomach, there is salivation and perhaps coryza, followed by nausea, and accompanied by some diuresis and considerable diaphoresis. If free vomiting occurs, these effects will quickly pass away; but if not, they will be prolonged, and with one or more exacerbations. In the latter case, too, there is more apt to be a laxative or even a purging effect, as is also the case after hypodermic injections. The respiratory mucous membrane generally shares in the increased secretion. Ipecac is therefore a nauseating expectorant and an emetic, with a cathartic tendency. Its emetic action is characterized by its slowness. If cephaëline is given, the nausea and salivation are more marked; if emetine, the nasal secretion is more in evidence. Very large doses are poisonous, the symptoms being those of emetico-cathartic irritants, but with great depression, which appears almost certainly due in part to central action. A cholagogue action is distinct. This cannot be explained on the theory of mechanical pressure upon the gall bladder from the retching, because it will occur when this is not present.

USE.—The expectorant and emetic uses of ipecac follow clearly from its action as above described, but not its antidysenteric. As an emetic it is not suitable for use in poisoning, as it is not prompt enough, and is too apt to be irritating. This action is, however, often of great value when we wish to carry its relaxing effect to the extreme, as in acute bronchitis. Very small doses of ipecac will often exert an anti-emetic action, and will also promote appetite and digestion. The chief use of the drug is, however, as an expectorant, in which it both increases the secretion and stimulates its removal, yet acts as a sedative or anodyne when there is annoying cough without much secretion. This action is quite prolonged, and the effect is easily maintained by repeated small doses. The diaphoretic action is an important accompanying factor. As an antidysenteric, ipecac is better adapted to the stomachs of savages than to those of most civilized persons, for the doses are so large (a drachm or more) that the treatment is heroic. De-emetinized ipecac is for this reason preferred, but it has been claimed that it lacks efficiency. The mode of action is not known. It is not impossible that in the true dysentery of the tropics, in which cases it is far the more efficient, it acts as a specific rectal antiseptic, as it is known to have antiseptic powers.

The preparations are numerous. The drug is very largely employed in the powdered form. As an expectorant, the dose is 0.03 to 0.06 gm. (gr. ss. to i.), as an emetic 1 to 2 gm. (gr. xv. to xxx.), as an antidysenteric 4 to 6 gm. (gr. lx. to xc.), or a full emetic dose followed by gram doses. The official fluid extract is given in corresponding doses of cubic centimetres or minims. The seven and one-half-per-cent. syrup and the ten-per-cent. wine are to be adjusted, in proportion to their strength, for the same requirements. The tincture of ipecac and opium, containing ten per cent. of each, is used when a specially sedative expectorant effect is desired, but not when we specially desire the clearing of the air passages. In the preparation of the last three the fluid extract of ipecac is employed. The same statement concerning selection applies to the powder of ipecac and opium (Dover's powder), having the same strength. The official troches contain, each, gr. $\frac{1}{3}$ of ipecac, and the troches of morphine and ipecac, each gr. $\frac{1}{40}$ of morphine and gr. $\frac{3}{40}$ of ipecac.

The rectal injection of ipecac for the treatment of chronic constipation has been tried, and it would seem that further experiments in such use are desirable.

Henry H. Rusby.

IPECAC, NORTH AMERICAN.—FALSE IPECAC, INDIAN PHYSIC, BOWMAN'S ROOT.—The roots of *Porteranthus trifoliatus* (L.) Britton, (*Gillenia trifoliata* Moench), and *P. stipulatus* (Muhl.) Britton, (*G. stipulacea*, Nutt.) (fam. *Rosaceæ*). These are pretty perennial herbs, with clustered, erect, or ascending stems, resembling the Geums, deeply three-parted leaves and white flowers. The former grows west to Missouri and south to Georgia; the second somewhat farther south and southwest. The roots grow from a hard, woody, and knotty crown about an inch in diameter. They are numerous, much and very crookedly twisted, knotty, and interlacing, especially the second species. The roots are annulate and transversely fissured and of a deep reddish color; thus giving them an appearance very similar to that of ipecac, which they have been used to substitute and adulterate. The bark is brittle, like that of ipecac, but the wood is thicker and much tougher, and has conspicuous slender medullary rays, which extend slightly into the bark. Strangely enough, the drug possesses properties similar to those of ipecac. It was highly prized by the aborigines as a mild emetic and nauseating expectorant, purgative also in larger doses, and was much used by the settlers. It is still employed to a considerable extent, and somewhat by physicians. The emetic property appears to reside in the peculiar neutral substance gillenin, which is extracted as a white powder, soluble in water and alcohol. It is probably a glucosidal mixture. "Gillenin" of commerce is a resinous extract, containing the other, and is given in doses of gr. iv. to vi. The dose of gillenia is 1 to 2 gm. (gr. xv. to xxx.).

Henry H. Rusby.

IRIDECTOMY (Gr., ἶρις, ἴριδος, the iris, and ἐκτομή, a cutting; ἐκ, out, and τομή, a cutting, from τέμνω, to cut), the operation of cutting out a portion of the iris for the purpose of forming an artificial pupil.

The instruments needed for the operation are: A spring speculum. A pair of fixation forceps, for steadying the eyeball (Fig. 2954); this must be light and catch accurately, and the teeth must not be too sharp and pointed, otherwise they may tear through the conjunctiva. A broad lance-shaped knife, the shape of which varies with the direction in which the iridectomy is to be made—if made outward (toward the temple), a straight knife may be used; if made inward or upward, the blade must be bent at an angle (Fig. 2955), according to the prominence of the nose or the upper margin of the orbit. If the anterior chamber is narrow, and the iris close upon the cornea, a very narrow von Graefe knife should be used in place of the lance-shaped one. The narrow knife represented in its actual size by Fig. 2956 has, in the hands of the present writer, almost entirely supplanted the lance knife in this operation; with it, it is possible to skirt the edge of the anterior chamber and make a large incision without risk of wounding the lens. The iris forceps, which should be lightly bent (Fig. 2957), should catch accurately, but when closed the arms of the forceps should come together only for a distance of 2 to 3 mm. from their end. The iris scissors; these may be bent at an angle (Fig. 2958), or curved on the flat (Fig. 2959); the blades must close tightly. Lastly, the rubber spatula, with which to replace the iris if necessary.

FIG. 2954.

Before the operation, the eye and its surroundings are to be thoroughly washed with a solution of corrosive sublimate of the strength of 1 to 5,000, the lids are everted, and the conjunctiva is washed with a piece of absorbent cotton dipped in the bichloride solution.

All instruments to be used are immersed, first in a 2.5-per-cent. solution of carbolic acid, and then in ninety-five per-cent. alcohol. The hands of the operator, as well as those of the assistant, and the parts adjacent to the eye are carefully washed with a solution of corrosive sublimate of the strength of 1 to 1,000.

OPERATION.—The patient is to be placed on a bed or operating-table, and an anæsthetic administered. In all cases of iridectomy, the patient should be brought completely under the influence of the anæsthetic before the operation is attempted. If the eye to be operated on is the right, the surgeon places himself behind the patient; if the left, he seats himself on the bed in front of the patient, that he may make the incision with his right hand. Complete anæsthesia having been brought about, the spring speculum is introduced and locked in place. With

the fixation forceps in his left hand, the surgeon seizes the conjunctiva on the same meridian as that in which the coloboma is to be, but at the opposite side of the cornea and close to it. Care is to be taken that the forceps exerts no pressure on the eyeball—it simply holds it or rolls it. The lance knife is now taken in the right hand, and its point entered either at the limbus or 1 mm. back from the circumference of the cornea. When the point has entered the anterior chamber, and the operator recognizes this by the sudden absence of resistance, the handle of the knife is lowered and the blade is pushed forward in the direction of the plane of the iris until an incision long enough for the purpose in view has been made. We shall see that the length of this incision varies with the size of the portion of iris that is to be removed.

The position of the point of the knife is carefully watched. The handle of the knife is still more lowered, so that its point comes almost in contact with the posterior surface of the cornea, and avoids contact with the anterior surface of the lens, which comes forward when the aqueous humor flows off. As the knife is now slowly withdrawn, its cutting edge is kept close to one or the other of the angles of the incision, and by this means the inner opening of the section is made of equal extent with the outer. We have said that the knife is to be slowly withdrawn, and this is most important. A quick withdrawal of the knife, and sudden evacuation of the aqueous, may be followed by intra-ocular hemorrhage or rupture of the suspensory ligament of the lens.

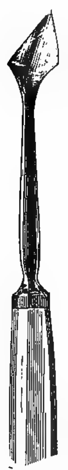
FIG. 2955.

The Narrow Knife.—If in place of the lance-shaped knife the narrow one of von Graefe is used, the procedure is as follows: Let us suppose an iridectomy is to be made upward, for the relief of glaucoma of the right eye. The anterior chamber is narrow, the iris and the lens system being well pushed forward; there is slight corneal haziness. The patient is to be completely anæsthetized, the speculum is introduced, and, as was described above, the eye is lightly fixed by means of the forceps. The surgeon stands behind the patient, the knife is held vertically in the right hand, and at the corneal margin its point is entered in the anterior chamber; the handle is now lowered and the point of the knife directed to the point of counter puncture, kept parallel with the plane of the iris, and made to skirt the edge of the anterior chamber. The distance between the points of entrance and of counter puncture is determined by the size which it is desired to give to the pupil. In completing the section the blade of the knife is given a slight inclination upward, so that the external and internal lips of the wound are directly over each other. The counter puncture is at the corneal margin, and the wound, when completed, lies opposite the peripheral insertion of the iris.

Whether the lance-shaped or narrow knife is used, it may happen now that the iris is spontaneously prolapsed in the wound and may be excised *in situ*. Ordinarily the next step of the operation is as follows: The fixation forceps is given over to an assistant, and the bent iris forceps entered, closed, through the incision; when the point of the forceps is opposite the sphincter of the pupil the blades are opened as widely as may be, and the iris is seized and drawn out through the corneal incision. The operator, now holding the iris thus secured and drawn out of the corneal wound to the requisite extent with the forceps in the left hand, takes the scissors in the right, and, holding them parallel with the corneal wound, cuts the exposed portion of iris. After the excision it is of great importance to see that the edges of cut iris are not entangled in the wound. There are different degrees of this entanglement—the edge of the cut sphincter may be drawn into the corneo-scleral section, or the ciliary portion of the iris may be thus entangled. In either case, care should be taken to replace the iris. This may be often accomplished by simply stroking the region of the incision with the rubber spatula, or it may be necessary to enter the wound again with the spatula and gently replace the iris. Should neither of these measures succeed, it may be necessary to use the iris forceps again and excise the portion thus entangled with the scissors.

After the operation it sometimes happens that hemorrhage into the anterior chamber takes place. In such an event the edges of the wound are gently separated by a Daviel spoon or by the india-rubber spatula, and the blood slowly runs out; or the eye is closed for a few minutes, and, waiting until the aqueous humor is secreted, the same attempt with the spatula is made again. If the hemorrhage is considerable and is continuous, sponges wrung out in ice water may be held for a few minutes against the eye until all sign of active bleeding has ceased. Any coagulum lying in the wound should be removed by means of the iris forceps.


FIG. 2956.

A bandage is now applied to the eye as after cataract extraction (see *Cataract*), and within six hours the bandage is renewed. On the following day, if there has been no accident, the patient may be allowed to leave his bed, but he should still remain for forty-eight hours in a moderately dark room. A few drops of a two-per-cent. solution of atropine should be instilled in the eye the second day, and this may be repeated twice daily so long as the patient remains under treatment. The length of the after-treatment will depend on the circumstances under which the operation has been performed, and when the iridectomy has been made merely for optical purposes, the confinement of the patient need be very brief. It sometimes happens that after the operation the sclero-corneal wound fails to unite, and that this condition of things lasts for days and even weeks. In cases of simple glaucoma,[1] immediately after the operation there may remain a marked increase of intra-ocular tension, and the anterior chamber is not at once restored. Indeed, the intra-ocular tension may increase, the iris and lens be pressed against the cornea, and the eye become painful and congested. In such a case as this the bandage can no longer be tolerated—indeed, it does harm. Occasional warm compresses may be used, and the pain quieted by injections of morphine, until the inflammatory symptoms have subsided.

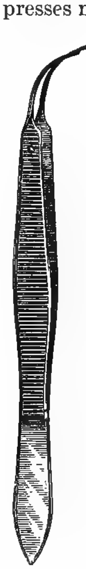
FIG. 2957.

In conclusion, it is proper to consider the care that must be exercised in performing an iridectomy, both for the accomplishment of our object and that no harm may ensue to the eye from the operation. It may happen that an inexperienced operator does not succeed in the excision of a piece of the iris, that he tears the iris from the ciliary body, that he causes a rupture of the hyaloid membrane, or that he wounds the anterior capsule of the lens. More than this, the operation, when performed *secundum artem*, is not absolutely free from danger. Occasionally, if rarely, such an eye is lost by purulent iridochoroiditis. When, after the operation has been performed, there ensues cystoid cicatrization of the iris in the wound, increased intra-ocular pressure may take place, or the eye may be lost by purulent irido-cyclitis. Mooren[2] found among two hundred and forty iridectomies one corneal suppuration, and von Graefe[3] saw two suppurations of the cornea after simple iridectomy.

HISTORY.—Before speaking of the uses of an iridectomy a brief reference to the history of the operation is in place. As early as 1711 the operation was performed by Woolhouse, and again in 1728 by Cheselden. The method of operation was modified and improved by Beer, in 1796. The new pupil, in these earlier operations, was made to enable

the rays of light again to enter the eye; it was done for optical purposes. Scarcely thirty years have passed since the applicability of iridectomy has been vastly increased. It was left for Albrecht von Graefe, in 1855, to prove that in this operation we had a means of reducing, in many cases, an increased intraocular tension. A new and greatly enlarged field for the operation was then found. Its influence in combating inflammation of the inner membranes of the eye was studied, and a more exact knowledge of the prophylactic action of an iridectomy, especially in its relation to subsequent operation for cataract, was acquired.

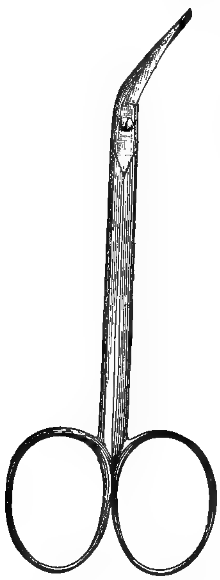

FIG. 2958.

USES.—In considering the conditions of the eye in which the iridectomy is made for optical purposes, the first in order would be corneal opacities. A central circumscribed corneal opacity, the rest of the cornea being transparent, offers the most favorable opportunity for benefit to the vision from a new pupil, The iridectomy in such a case should be made as small as possible, for the new pupil, under the influence of light, will not contract and dilate as the normal pupil does. The most advantageous position for such a pupil is either opposite the inner side, or at the lower and inner side of the cornea.

The pupil may be either free or adherent to the cornea at a single point, or its entire margin may be fast to the corneal cicatrix. In cases in which the iris is completely adherent to the cornea an iridectomy is impossible.[4] If the anterior chamber is no longer present, and the cornea is flattened, opaque, and its curvature gone, iridectomy is useless, if not an actual impossibility.

In cases of keratoconus an iridectomy has been of service. Here the object of the operation is twofold—first, to offer to the rays of light a portion of the cornea relatively of normal curvature, and secondly, to secure a permanent reduction of the intra-ocular pressure.

Again, an iridectomy is often indicated when the region of the pupil is occupied by a membrane, the remains of an exudation. We shall speak later of the value of iridectomy when there are adhesions between iris and lens capsule, and when these adhesions furnish a cause for relapse in iritis.

When a fragment of metal has penetrated the cornea and lodged on or in the iris, an iridectomy must often be made in order to remove the foreign body, and in such a case a small wound is to be made at the limbus, and then with the iris forceps a fold of the iris, including the foreign body, is to be gently seized and excised. It happens in such cases, sometimes, that a piece of steel lies on the surface of the iris, or is lightly embedded in its tissue, and we are enabled by the use of the magnet to remove the foreign body through a corneal wound without causing prolapse of the iris.

An iridectomy is indicated in certain cases of opacity of the lens. Especially does it benefit certain cases of zonular cataract, in which the centre of the lens is clear, while around it is a cataractous layer or zone. Certain of these cases are progressive. It is for the stationary form that the operation is indicated (see *Cataract*). If the central opacity is not extensive, and if, upon dilating the pupil with a mydriatic, the patient secures a reasonable vision and can read, a new pupil can be made inward. Von Graefe[5] advised in such cases that the incision be made with the lance knife inward, not at the margin of the cornea, but a line within the limbus; then with the forceps the pupillary margin of the iris is seized and a small piece excised. The new pupil should be as small as possible, on account of the dispersion of light through the lens, and on account of the irregular astigmatism that is usually found in the periphery of the lens.

Iridodesis, or displacement of the pupil, has been recommended in these cases, and the form of the pupil secured by this operation is most desirable; but experience has shown that it is not without its dangers, and the anterior synechia which it entails may be a source of lasting injury to the eye.

Anterior polar cataract, in which the peripheral portions of the lens are transparent, furnishes sometimes an indication for iridectomy. In such a case the condition of the lens and the vision must be carefully examined after artificial dilatation of the pupil.

So, too, in cases of secondary cataract, either after an extraction or when a traumatic cataract has undergone spontaneous absorption, an iridectomy may be of benefit. In the majority of such cases, however, either a discission of the membrane or its removal from the region of the pupil is necessary.

We have thus far considered the operation of making a new pupil in the light of its serving an optical purpose. There is an equal, if not larger, application for it in combating inflammations of the eye. One well-recognized effect of an iridectomy is the consequent reduction of intra-ocular tension.

In cases of chronic iritis[6] and irido-choroiditis iridectomy holds a foremost place in treatment. The most frequent cause of recurrence in iritis is found in the adhesion that takes place between the posterior surface of the iris and the anterior capsule. The broader these adhesions are the more frequent is the recurrence, and with complete fixation of the pupil, further complications occur in the form of chronic choroiditis, and this may go on to atrophy of the eyeball and loss of sight. The period at which the iridectomy is made in these cases is of great importance. It should not be made when the eye is in a condition of acute inflammation. Cases of irido-choroiditis, in which a certain degree of atrophy of the eye has taken place, have been arrested by the performance of iridectomy. Von Graefe, in the article we have cited, shows how here the stasis and congestion in the choroidal vessels are relieved, and the nutrition of the vitreous humor is improved by the operation.

In cases of exclusion of the pupil, that is, where there is complete adhesion between the edge of the pupil and the capsule of the lens, and consequently no communication between the anterior and posterior chambers, an iridectomy is indicated. As the object of the operation in such cases is the re-establishment of connection between the anterior and posterior chambers of the eye, success will depend on the condition of things back of the iris. If there is firm membranous exudation there the operation will be difficult, and may have to be repeated again and again.

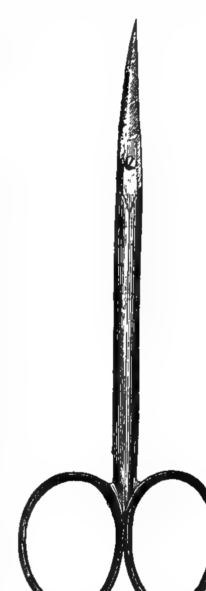

FIG. 2959.

Another class of cases in which iridectomy may be practised to ward off inflammation is that in which there are local changes in the iris, as in the case of small cysts, usually following a penetrating wound and situated at the sclero-corneal junction; or, again, that in which a foreign body has penetrated the cornea and lies in the iris tissue, when its removal may be impossible without iridectomy.

In cases of extensive ulcerations of the cornea, or suppurative keratitis with tendency to hypopyon, iridectomy often renders service. The operation would not be indicated if the corneal affection were likely to heal and ultimately leave the centre of the cornea clear, nor in cases in which the corneal disease was dependent on purulent or diphtheritic conjunctivitis. The operation is rather for cases of idiopathic keratitis in which there has been a considerable loss of corneal surface, and here, as von Graefe pointed out, the reduction of the intra-ocular tension relieves the strain upon the cornea and allows the process of repair to go on.[7]

In cases of beginning staphyloma of the cornea, and cases in which there has been corneal ulceration with entanglement and prolapse of the iris, with staphylomatous tendency, an iridectomy is necessary. In these cases the power of resistance of the cornea, even to the normal intra-ocular pressure, is reduced, and the operation should be made even before there is an increase of the tension, with a view to averting it. More than this, the operation is of value in combating the severe pain that is present even if the eye is blind, and in warding off sympathetic affection of the fellow-eye.

Partial staphyloma is often relieved by an iridectomy.

We come now to a consideration of the value of an iridectomy in cases of glaucoma. For the relief of this disease the operation was first performed by von Graefe, in 1855.[8] The incision is to be made at the sclero-corneal junction, and of sufficient extent to remove a segment of the iris from pupillary to ciliary margin, and at least 3 mm. in width. The results attained by the operation will depend on the period of the disease at which it is undertaken. It may be said in general that the sooner the operation is made after the disease has declared itself, and before serious changes have occurred in the structures of the eye, the better. In the ordinary history of a case of glaucoma there are so-called premonitory symptoms. These are of periodic occurrence, leaving the eye in the interval apparently perfectly well. Among these symptoms are increase in the tension of the eyeball and a rapid increase in the amount of the presbyopia, compelling the patient to make frequent change in the strength of the reading-glass; there is periodic dimness of sight; on looking at a light the patient sees a rainbow or halo around it; there is pain in the forehead and temples; there is contraction of the visual field, and generally this limitation begins at the inner or nasal side. With these symptoms, some or all of which may be present, there may be cloudiness of the aqueous or vitreous humor, and the pupil is sluggish and moderately dilated. On the optic disc we see arterial pulsation. So soon as these periodic symptoms leave no longer a normal pupil, and so soon as a lasting impairment of the vision takes place, we can no longer speak of the premonitory stage; the disease of glaucoma is established, and iridectomy can no longer with safety be delayed. The prognosis is most favorable when the iridectomy has been performed during the premonitory stage.

In acute inflammatory glaucoma the iridectomy may accomplish good results, if it is made at a sufficiently early period. Even if the sight is reduced to a mere quantitative perception of light, the operation may restore vision, provided that the sight was good before the attack. At this period of the disease the operation is attended often with peculiar difficulty. The increased intra-ocular tension causes the lens and iris to be pressed forward and the anterior chamber to be narrowed. Here the narrow von Graefe knife can be, with great advantage, substituted for the lance knife in making the section. The iridectomy in glaucoma should be large and peripheric. Indeed, we have seen cases in which the iridectomy could be accomplished with no other instrument.

Von Graefe gave the name glaucoma fulminans to a class of cases in which blindness ensues in apparently healthy eyes within a few hours. He explains the process as one in which the sudden increase of intra-ocular tension shuts off the supply of arterial blood to the retina. Here, if the iridectomy is to bring any relief, it must be made within two or three days of the beginning of the attack.

In chronic inflammatory glaucoma the iridectomy will often arrest the disease and preserve such vision as the patient has at the time of the operation. The prognosis in these cases should be guarded, however, and the result will largely depend upon the extent of the limitation of the visual field, and upon the degree of the excavation of the optic disc. The greater the intra-ocular tension at the time of the operation, the better are the chances from the iridectomy. If, after the operation, there should still be increased tension, von Graefe has recommended that another iridectomy should be made, diametrically opposite the first, so as to cut off the two halves of the iris from each other. There are cases, however, of chronic inflammatory glaucoma in which, notwithstanding all treatment, blindness ensues in consequence of progressive atrophy of the optic nerve, and not through a recurrence of the glaucomatous inflammatory symptoms with increased tension.

In cases of glaucoma in which there are no evident inflammatory symptoms, iridectomy often proves of service. This class of cases has received the name of glaucoma simplex, or amaurosis with excavation of the optic nerve. Von Graefe pointed out that in most of these cases an iridectomy reduces the tension of the eyeball to its normal condition and keeps it there. In some cases the tension is reduced and the vision remains for a time as it was directly before the operation, and then fails; the tension is later on again increased, and only after a second iridectomy is the process brought to a standstill. In a certain number of cases von Graefe[9] found that the iridectomy actually increased the tension instead of diminishing it, and the sight was suddenly lost as if by an acute attack of glaucoma; in other words, the operation precipitated the fatal issue.

As we owe to von Graefe the discovery of the fact that iridectomy alone permanently reduces the abnormally increased intra-ocular tension, so do we owe to him a knowledge of the class of cases in which the operation may be employed. According to von Graefe,[10] there is hardly any inflammatory disease of the eye which may not lead in its course to secondary glaucoma. That we may enumerate the cases in which an iridectomy may be called for, we will briefly allude to the diseases in which secondary glaucoma most frequently supervenes. Of the affections of the cornea, diffuse keratitis comes first in order, then chronic keratitis, associated with the so-called sclerotico-choroiditis anterior, pannus, cicatrices of the cornea, and especially cicatricial ectasia of the cornea. In this last class of cases the iridectomy is to be made, not alone when there are signs of increase of tension, but at an earlier period, and with a view to protecting the eye against an attack of secondary glaucoma.

Von Graefe has described a peculiar affection of the cornea which is prone to develop secondary glaucoma, and calls for an iridectomy for its relief. This is the so-called "band-shaped" keratitis, which occupies the centre of the cornea, the rest of the cornea being transparent. The opacity extends over that portion of the cornea which would be exposed when the lids are but slightly open. When this affection is recognized, an iridectomy should be made as early as possible. Secondary glaucoma supervenes on plastic iritis, when numerous posterior synechiæ have formed, and in iritis serosa. In both classes of cases an iridectomy is the only measure which offers a hope of permanent relief.

Traumatic cataract leads sometimes to secondary glaucoma, and an iridectomy may, under certain circumstances, afford relief. With rupture of the anterior capsule and rapid swelling of the lens substance, the iris is pushed forward, and increased tension is the result. Von Graefe has here pointed out that, if the signs of secondary glaucoma are present, either simple iridectomy or extraction of the lens is indicated. The eyes of young children withstand the deleterious effects of an increased tension much better than do the eyes of adults.

In cases of dislocation of the lens, if symptoms of glaucoma arise, von Graefe advises that an iridectomy should be made, especially if the dislocation is moderate, and the iris pushed forward to a limited extent. The incision should be as near the periphery as possible, on account of the danger of the vitreous humor entering the anterior chamber and pushing back the iris in such a way that its excision becomes difficult. The operation should not be undertaken in these cases until the patient is completely under the influence of an anæsthetic and the muscles are completely relaxed, otherwise there is great danger of escape of vitreous, and consequent intra-ocular hemorrhage.

Secondary glaucoma supervenes on serous choroiditis, and if repeated paracentesis fails permanently to reduce the increased tension, and the disease resists other treatment, an iridectomy should be made.

In posterior staphyloma, or sclerectasia posterior, secondary glaucoma may, and often does, supervene.[11] Von Graefe states that the disease here always attacks both eyes sooner or later, and that it assumes the character of glaucoma simplex, or that of the inflammatory form. The secondary affection, if its character is not early recognized and an iridectomy made, leads to grave impairment, or even to total loss, of sight.

Richard H. Derby.

[1] Graefe-Saemisch, iii., pp. 359, 360.
[2] Ophth. Beobacht., Berlin, 1867.
[3] Archiv f. Ophth., Bd. xii., 1, p. 214.
[4] Graefe-Saemisch, Bd. iii., S. 340.
[5] Archiv f. Oph., i., Band ii., p. 243.
[6] *Ibid.*, ii., ii., 202.
[7] *Ibid.*, ii., ii., 243.
[8] *Ibid.*, iii., ii., 456.
[9] *Ibid.*, xv., iii., 202.
[10] *Ibid.*, xv., iii., 121.
[11] *Ibid.*, iv., ii., 153, and *ibid.*, xv., iii., 173.

IRIDOTOMY.—Iridotomy and iritomy are the names which have been given to the operation of cutting the iris, thus making a distinction between that operation in which the iris is simply cut, and the *iridectomy* in which a portion of it is removed.

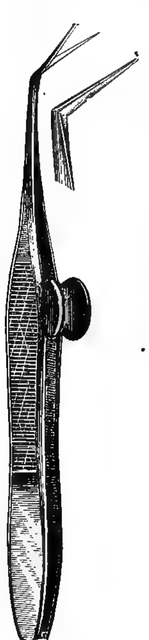

FIG. 2960. — De Wecker's Scissors.

In a normal eye it is not difficult to make a cut in the iris, either radial or tangential, with a Graefe knife, and that too without wounding the lens or its capsule; but iridotomies are usually done on eyes in which the conditions are far from normal, in which the lens has been removed, and in which the pupil is so blocked by iris, or thickened capsule, or both, that neither iridotomy nor capsulotomy can be considered exclusively descriptive of the necessary operation. In such cases the method of de Wecker is usually followed. A small cut is made with a lance knife or a Graefe knife as for a cataract operation, the points of de Wecker's scissors (Fig. 2960) are introduced closed and nearly on the flat, and are then allowed to open so that the sharp point shall pierce the iris and pass below it until the limit of the proposed incision has been reached. Now the cut is made by closing the scissors, after which the instrument is withdrawn and the operation is complete. A single slash in the iris is not always sufficient to secure an open pupil, so the operation is sometimes varied by making a second cut before the scissors are removed, this being made in such a manner as to leave a slender tongue of iris the point of which will roll up on itself leaving a triangular pupil. The after-treatment is the same as that following iridectomy.

William S. Dennett.

IRIS, CONGENITAL ANOMALIES OF.—Congenital anomalies of the iris are usually associated with malformations of other ocular structures and frequently with congenital defects elsewhere, such as harelip, cleft palate, etc. They are dependent in great part upon hereditary influences, although it seems highly probable that in certain cases they may be due to inflammatory processes occurring in the eye during fœtal life. Poor vision is the rule, but it is usually to be attributed to the insufficient development of the eye as a whole rather than to the defects in the iris. Not infrequently there is microphthalmos of one or of both eyes. Errors of refraction of high degree are common and add to the general impairment of vision. In addition to this, such congenitally defective eyes are especially subject to diseases, particularly choroiditis and cataract.

Membrana Pupillaris Perseverans (persistent pupillary membrane, Fig. 2961). In the fœtus the entire lens is surrounded by a vascular membrane, the *tunica vasculosa lentis*, the blood supply of which is derived chiefly from branches of the *arteria centralis* that pass around the edge of the lens and anastomose on its anterior surface. The network of vessels is particularly free at the equator of the lens and least marked at its anterior pole. The portion of the membrane occupying what is to be the pupillary area is known as the pupillary membrane, and as the iris is developed an anastomosis takes place between its vessels and those of the membrane. Usually at birth all of these vessels and the membrane itself have disappeared, but exceptionally portions of them persist throughout life. When this is the case there is rarely found anything that resembles a true membrane, but simply a number of strands of tissue, often highly pigmented, which arise from the anterior surface of the iris and project into the pupil. The strands may hang freely in the pupil, they may be adherent to the capsule of the lens, or they may extend entirely across the pupil forming a network in front of the latter. Not uncommonly there remains only a single fine thread passing across the pupil. In rare instances the strands have been seen united with the cornea. That these strands really represent vessels has been proven by microscopic examination. Blood corpuscles have been seen in them and they have been artificially injected shortly after birth. They usually take origin from the small circle of the iris, but they may be given off farther toward the periphery. Rarely a portion of the pupillary membrane itself remains on the lens capsule and may be mistaken for an anterior polar cataract.

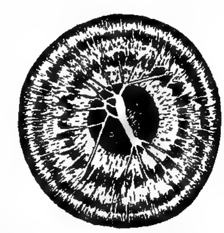

FIG. 2961.—Persistent Pupillary Membrane. (After von Hippel.)

This is one of the commonest anomalies of the eyes. Fuchs says it is frequent in new-born infants, but usually disappears. It is more common in the right eye than in the left, and in one eye than in both. It occurs more frequently in females than in males. As a rule the strands do not interfere with vision, but in a few cases the sight has been so much impaired as to necessitate their removal by operation. They are sometimes mistaken for synechiæ, although they can readily be distinguished from the latter by their distensibility and by their arising from the anterior surface of the iris.

Corectopia (displacement of the pupil). A slight degree of corectopia must be regarded as normal, since the pupil is usually not exactly central but situated a little to the nasal side. In marked cases of the anomaly the pupillary margin may lie within 1 to 2 mm. of the corneal limbus. The displacement is usually upward and outward and the pupil is apt to be small and to present irregularities in its contour. The iris may be perfectly normal and react normally to light, and in such cases the condition is commonly unilateral and not associated with other ocular defects. Often, however, corectopia occurs in conjunction with other congenital anomalies such as buphthalmos, albinism, coloboma of the lid or iris, and microphthalmos. Not infrequently it is accompanied by ectopia of the lens, both eyes as a rule being affected. In

such cases the lens and pupil are most often displaced in opposite directions and there is apt to be iridodonesis. The lens is usually clear but noticeably small and may present a greater or less degree of coloboma. It is noteworthy that in cases of corectopia coloboma of the choroid or retina has never been observed. Remains of the pupillary membrane are sometimes seen. In some cases the iris may be discolored and atrophied, and the radial striæ run in such directions as to produce the appearance left by an iridectomy when the root of the iris has been incarcerated in the wound. For this reason it has been suggested that the condition here is due to an adhesion of the growing iris to the periphery of the cornea as the result of an intra-uterine iritis.

The vision may be normal or greatly impaired, the impairment in these cases being dependent upon the optical defects rather than upon changes in the fundus. When the edge of the lens is opposite the pupil, monocular diplopia may occur.

Dyscoria (irregularity in the shape of the pupil). It is very common to find a number of pigmented tags extending from the pupillary margin into the pupil. These are due to a proliferation of the pigmented epithelium lining the posterior surface of the iris. In some cases they are quite large and they have been known to break away and lie free in the anterior chamber. They are to be distinguished from posterior synechiæ due to iritis by the fact that they are never adherent to the capsule of the lens. Sometimes they are regarded as remains of the pupillary membrane, but differ from the latter in arising from the margin of the pupil. Very similar projections are normally present and highly developed in the eyes of horses. Dyscoria may also be the result of posterior synechiæ following fœtal iritis.

Polycoria.—Strictly, this condition does not exist, since no authenticated case has been described in which an iris contained more than one pupil surrounded by a sphincter muscle. Cases have occurred, however, in which there were a number of openings in the iris in addition to the single normal pupil. They usually appear as radial clefts in the iris tissue surrounding the pupil and may be as high as sixteen in number. Less often the defects occur at the root of the iris and are sometimes regarded as instances of iridodialysis. The appearance of polycoria may also be produced by a bridge coloboma of the iris or by a persistent pupillary membrane.

Irideremia, Aniridia (congenital absence of the iris). From a clinical standpoint this may be either complete or, less often, incomplete. If a microscopical examination could be made in every case, however, it is probable that some remains of the iris would always be found. When the irideremia is complete, both eyes usually show the defect. The incomplete form may closely simulate a coloboma, in fact it is impossible to draw a sharp distinction between the two conditions. The influence of heredity is more apparent in irideremia than in any other congenital anomaly of the eye.

The pupil ordinarily appears a little less dark than normal, and by artificial light under suitable conditions it may appear luminous to the observer. The ciliary processes usually are not visible, probably because they are not well developed. The accommodation, however, is perfectly normal. In most cases a strong light is not borne well by the patient, but this is not always true. The vision is as a rule very defective, due in most instances to other complications rather than to the mere absence of the iris, and there is frequently nystagmus and sometimes strabismus. Other congenital anomalies, such as persistent hyaloid artery, ptosis, and microphthalmos, may be present. Corneal and vitreous opacities, choroidal atrophy, and detachment of the retina occur, but the most frequent complication is cataract, most often of the anterior or posterior polar variety. Luxation of the lens, usually upward, may be present at birth or take place later in life.

A not infrequent and particularly interesting complication is glaucoma. This fact has been brought forward as an objection to the theory that glaucoma is due to a blocking of the filtration angle by the iris, but is really in favor of such a view because anatomical investigations have shown that in irideremia there is always a small stump of iris either free or firmly adherent to the periphery of the cornea.

A number of theories have been advanced to explain the occurrence of the anomaly, none of them very satisfactory. The best explanation seems to be that of Manz. According to this observer, the proper development of the iris is mechanically prevented by a delayed separation of the lens and cornea. The frequent occurrence of corneal opacities and of anterior polar cataract certainly supports this explanation. A highly theoretical view is that an intra-uterine glaucoma causes the iris to be pressed against the cornea, thus preventing its further development.

Coloboma of the Iris.—In typical cases this consists of a cleft in the iris which extends into the pupil and with the latter forms a pear-shaped opening (Fig. 2962). Less often the edges of the gap are nearly parallel so that the appearance of a keyhole is produced, and in rare instances the edges of the coloboma may converge toward the pupil. The coloboma may be complete, the opening extending to the ciliary margin, or incomplete, a bridge of iris tissue remaining at the apex of the gap. Usually it involves from one-sixth to one-fourth the circumference of the iris and is placed downward or downward and inward. In the lowest grade of the anomaly there is simply a slight notching of the pupillary margin. The pigmented posterior layer of the iris is usually visible along the edges of the opening and may send irregular projections into the latter, or, in the form of a black membrane, it may more or less completely close in the gap. Sometimes a band of tissue unites the edges, forming the *bridge coloboma* (Fig. 2963). The bridge usually arises mainly from the anterior surface of the iris and possibly represents the remains of the pupillary membrane, but it may arise directly from the edges of the opening. In some instances a strand of tissue has been found connecting the apex of the coloboma with the optic disc.

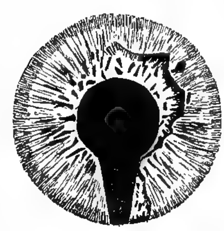

FIG. 2962.—Coloboma of the Iris. (After Seggel.)

The sphincter muscle passes along the edges of the coloboma and in the incomplete type may encircle the apex. The pupil reacts in the usual way both to light and to myotics and mydriatics. A mydriatic may cause a small coloboma to become evident which was previously invisible. The pupil is usually displaced downward, less often upward. The appearance of a coloboma may be simulated by a highly pigmented streak that has the shape and position of a typical coloboma, by a localized thinning of the iris, or by a streak in which the pigment is scantily present—*pseudo-colobomata.*

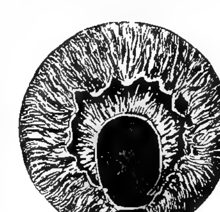

FIG. 2963.—Bridge Coloboma. (After Saemisch.)

Coloboma of the iris is among the most common congenital anomalies of the eye. It usually occurs in one eye only, most commonly the left, and in most cases it is associated with a coloboma of the choroid or ciliary body. Two colobomata have been met with in the same iris. While in typical cases the defect is directed downward, cases have been observed in which it was directed inward, outward, or even directly upward. Sometimes the defect is so great that it becomes a question whether it should not be regarded as an example of incomplete irideremia. In more than half the cases of atypically directed coloboma the shape of the coloboma is typical. Bridge coloboma has been observed in these cases. In most of them there is no coloboma of the

deeper structures, and when the latter occurs it usually corresponds in direction to the defect in the iris. Cases have been reported, however, in which an upward coloboma of the iris was associated with a downward coloboma of the choroid.

The explanation of typical coloboma of the iris seems simple enough. Its downward direction and its frequent association with coloboma of the choroid point clearly to some relationship with the fœtal cleft. Normally there is at no stage in the development of the eye a cleft in either the choroid or the iris, so that the defect cannot be due, as often supposed, to imperfect closure of clefts in these structures. On the other hand it is perfectly possible that a delayed closure of the cleft in the secondary optic vesicle would lead to an imperfect development of the choroid in this region, and since the iris grows as a prolongation of the choroid, this in turn would lead to a localized defect in the iris also. According to this theory, the coloboma of the iris must always be preceded by a defect in the choroid. In those cases in which no such defect is found, it is assumed that the latter was repaired after the iris had been sufficiently hindered in its development to produce a coloboma, or that the defect in the choroid was small and occurred only in the ciliary region. Cases of coloboma of the choroid without coloboma of the iris are readily explained by assuming that the fœtal cleft was delayed in closing only posteriorly.

This theory, however, fails to explain satisfactorily the atypical cases of coloboma, for instance the cases in which the coloboma is directed upward. To explain the latter, Pflüger assumes that a torsional rotation of the eye occurs during fœtal life, but if this is the case it is difficult to understand why the macula develops in its normal position. It is still more difficult to explain the cases in which a coloboma of the iris differs greatly in direction from a coloboma of the choroid in the same eye, or the cases in which one iris shows two colobomata. It seems likely that these atypical cases and possibly certain cases of corectopia as well, are all examples of incomplete irideremia and are dependent upon the same factors which give rise to the latter anomaly. For it is readily conceivable that the factors which would lead, if acting strongly, to complete irideremia, if acting less strongly would give rise to incomplete irideremia, coloboma of the iris, or simply corectopia. The cases in which there is an atypically directed coloboma in one eye and complete irideremia in the other support this view. And Theobald's case of a mother with double-sided upward coloboma of the iris, whose child had complete irideremia in each eye, suggests not only this as the explanation, but also that the predisposing factors are hereditary and hence probably not, as sometimes supposed, of an inflammatory nature.

Anomalies of Pigmentation.—The variations in the color of the iris are dependent upon the amount of pigment in its stroma, the posterior layers of epithelium being always densely pigmented except in cases of albinism. In a blue iris there is very little pigment in the stroma, and from this all gradations are met with up to the black eye of the negro in which the stroma is intensely pigmented. The epithelial layers are pigmented at birth, but the stroma does not contain pigment until later so that the eyes of babies are always blue or gray. The irides of the two eyes may differ entirely in color, one being a decided blue and the other a dark brown—*heterochromia*. Or a blue iris may show a brown sector or be studded over with brown patches. In *melanosis oculi* the iris together with other structures of the eye, conjunctiva, sclera, optic nerve, and choroid, may show circumscribed areas of deep pigmentation comparable to the pigmented moles of the skin. Like the latter they may form the starting-points for malignant tumors.

In *albinism* there is a marked absence of pigment in the iris as well as in other parts of the body which normally contain pigment. The color of the iris in this condition depends to some extent upon the illumination and it may appear of a lilac, rose, or yellowish-white hue. In structure the iris is perfectly normal, but the pupil is always very narrow and dilates but little in a feeble light. Photophobia is a marked symptom and as a rule the eyes are almost amblyopic. Nystagmus is a frequent complication. The fact that in the fœtus pigment is so sparingly present suggests that albinism represents a lack of development. Heredity is undoubtedly an important factor in its occurrence. It is interesting that this anomaly is relatively common among negroes.

For the literature on congenital anomalies of the iris, reference should be made to von Hippel, "Die Missbildungen und angeborenen Fehler des Auges," Graefe-Saemisch "Handbuch der gesammten Augenheilkunde," 2. Auf., ii. Bd., ix. Kap. *Frederick Herman Verhoeff.*

IRITIS.—Iritis, or inflammation of the iris, is one of the common affections of the eye. It arises from a variety of causes, may attack one or both eyes, and, while almost always amenable to treatment if recognized in its inception and judiciously managed, it usually impairs the sight more or less seriously and permanently damages the integrity of the eye if allowed to run its course unchecked, or if improperly or only tardily treated. It is of the first importance, therefore, that its true character should be recognized at the outset, and that the requisite therapeutic measures should be resorted to without delay. The diagnosis of inflammation of the iris is commonly not a difficult matter, and the indications for its treatment are usually plain. It is nevertheless true that it is frequently confounded with other forms of inflammation of the eye, and improperly treated; and in consequence of this, or because of the ignorance or indifference of those whom it attacks, it is by no means an uncommon cause of blindness.

Speaking generally, the presence of iritis is to be suspected whenever, without increase of intra-ocular tension or other evident cause, pain in and around the eye, usually worse at night, is complained of, and is accompanied by pericorneal subconjunctival injection and a contracted pupil. This concourse of symptoms does not necessarily indicate the presence of iritis, but it is distinctly suggestive, and should lead to a careful search for other evidences of its existence. A dull, lack-lustre appearance of the iris, with appreciable change of color and more or less swelling of its tissue; immobility of the pupil, and perhaps loss of its circular form; loss of transparency of the aqueous humor, and frequently of the cornea as well, with consequent indistinctness of vision; adhesions between the margin of the pupil and the anterior capsule of the lens, which, however, are frequently not evident until a mydriatic has been used; and in severe cases a grayish opacity of the pupil from the deposition of an organized exudate upon the lens capsule, are the other changes which should be sought for, and which, if found, establish the diagnosis beyond question.

Among the causes of iritis, syphilis doubtless deserves the most prominent place. Traumatism is another frequent cause, and not only when the iris itself is involved in the injury, but also when the cornea, lens, or ciliary body is wounded. Rheumatism and gout, diabetes, and the acute infectious diseases, also deserve prominent mention in this connection, and gonorrhœa, though an infrequent cause, occasionally gives rise to it, the ocular inflammation having the same relation to the urethral disease that gonorrhœal arthritis has. Iritis may also be a consequence of inflammation of other structures of the eye, as, for instance, abscess or perforating ulcer of the cornea.

There is also another cause of iritis to which the writer is disposed to attach great importance, and which he believes to be an essential factor in the production of several apparently distinct varieties of the disease. He refers to an influence transmitted through vaso-motor or "trophic" nerves, which is frequently reflex in its character, and is probably always dependent upon structural changes in gray nerve matter, either in the cerebral ganglia themselves, or in the ganglia connected with the fifth nerve, or in both. It is such an influence as this, he believes, that determines the development of sympathetic iritis,

the iritis which is frequently found associated with herpes zoster ophthalmicus, that which occasionally follows malarial attacks, and probably also certain cases of serous iritis. In this category belong also those cases of iritis which he thinks have been rightfully ascribed to reflex dental and uterine irritation, as well as certain intractable forms of irido-keratitis, which are not infrequently accompanied by anæsthesia of the cornea. Obstinacy and intractability are the common characteristics of these several varieties of iritis, and in the pathological changes which they exhibit, there are also striking resemblances.*

The consequences of a severe attack of iritis which has not been properly treated are disastrous to the integrity of the eye in several ways. In the first place, especially in syphilitic iritis, the other structures of the eye are liable to become involved in the inflammatory process, the ciliary body, choroid, retina, lens, and cornea not infrequently suffering irreparable damage. Again, the pupil may be closed or obstructed by an organized membrane (occlusion), so that vision is reduced to mere perception of light; or the iris may become adherent to the anterior surface of the lens, at its pupillary margin only (exclusion), or throughout its whole extent (complete posterior synechia). In the two former conditions operative interference may accomplish great good; in the latter, the prognosis is less favorable, as the nutrition of the eye is apt to be seriously impaired, and in time the deeper tunics suffer and the lens loses its transparency. Sympathetic inflammation of the fellow-eye is another result which, though not of frequent occurrence, happens often enough to deserve mention.

Although there are so many causes of iritis, there are not, strictly speaking, so many different kinds of iritis.

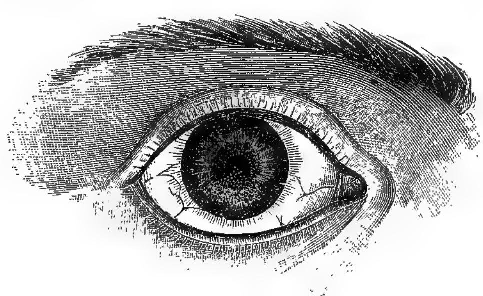

FIG. 2964.—Serous Iritis. (Noyes.)

Indeed, it seems scarcely necessary to describe more than three varieties—plastic iritis (*iritis plastica*), suppurative iritis (*iritis suppurativa*), and serous iritis (*iritis serosa*, Descemetitis) (see Fig. 2964). The first-named variety is by far the most comprehensive. It includes most cases of syphilitic, of rheumatic and gouty, and of sympathetic iritis. Many cases of traumatic iritis are also of this character, and so are most of those which have been spoken of as due to "trophic" nerve influence. Suppurative iritis is less common. It is usually the result of penetrating wounds of the eyeball, or of operations in which the globe is opened, and is almost always due to the presence of pyogenic micro-organisms. It may also follow extensive suppurative inflammation of the cornea. Iritis serosa is a disease of by no means rare occurrence, but it is one about the pathology of which we have yet much to learn. There is no doubt but that the iritic inflammation is often only a part of an inflammatory process which involves the entire uveal coat. In some instances it seems to be dependent upon a rheumatic diathesis, and in others, as has already been intimated, upon a reflex or "trophic" nerve influence. It occasionally exhibits a mixed type, the characteristic dots upon the membrane of Descemet and a tendency to glaucomatous tension, which belong to the usual form of the disease, being associated with a disposition to the formation of posterior synechiæ. When, as is very commonly the case, the deeper portions of the uveal tract are involved in the inflammatory process, cloudiness of the vitreous humor and the development of floating opacities in it are of frequent occurrence. It usually runs a protracted course, and does not always respond satisfactorily to treatment. When the tension is above normal the pupil is apt to be dilated rather than contracted, and under such circumstances the supervention of a distinctly glaucomatous condition is to be feared.

All of the varieties of plastic iritis are characterized by a tendency to the formation of an organized exudate, but this tendency is much more marked in some than in others. It is especially so in sympathetic iritis, in the iritis of herpes zoster ophthalmicus, and, in fact, in all those forms of iritis which appear to be due to "trophic" nerve influence. In syphilitic and in rheumatic iritis this tendency usually manifests itself by the formation of adhesions between the pupillary margin of the iris and the capsule of the lens, but in sympathetic and the other allied forms of iritis a felt-like exudation develops upon the posterior surface of the iris, causing it to adhere throughout its whole extent to the lens, and the pupil is commonly occluded by similar material. Under such circumstances, also, projecting portions of the anterior surface of the iris may become adherent (without ulceration) to the inner surface of the cornea (anterior synechiæ).

A characteristic, but by no means constant, feature of syphilitic iritis is the development upon the anterior surface of the iris, and occasionally upon its posterior surface in the pupillary zone (Bull), of yellowish or reddish-brown nodules, which project forward into the anterior chamber, and sometimes even press against the cornea. Usually there are not more than one or two present; but they may be so numerous, and of such size, as to fill the anterior chamber. They occur more frequently in the iritis which develops during the secondary stage of the disease, and are then of the nature of condylomata; those met with in the iritis of tertiary syphilis are gummata. Hence the former variety of iritis is sometimes designated as *iritis condylomatosa* and the latter variety as *iritis gummosa*. They may undergo absorption, or may disappear through fatty or purulent degeneration. The inflammation of the iris tissue being more intense over the area which corresponds to their base, we find here a special tendency to the formation of adhesions to the lens capsule. All of the varieties of iritis may be complicated by hypopyon, though it is more common in the purulent and syphilitic types. It is due to the deposition from the aqueous humor of leucocytes and fibrin, and, as a rule, undergoes absorption slowly.

Some authors describe a fourth variety of iritis, which they call "spongy iritis." It is, however, only a type of the plastic variety, in which there occurs a low form of plastic exudation in the anterior chamber, which presents a cyst-like appearance, and might be mistaken for a dislocated lens. Such cases are commonly of rheumatic origin.

A chronic form of plastic iritis is occasionally met with, in which the inflammatory symptoms are but slightly marked. It is often associated with a rheumatic or gouty diathesis, and shows a disposition to recurrence. Points of adhesion between the iris and lens are apt to take place before the true nature of the attack is discovered, as it develops insidiously, and is unattended by pain or other symptoms calculated to alarm the patient and induce him to seek medical advice.

In examining a case of suspected iritis the use of "oblique illumination" is of great assistance, since it enables one to detect slight changes in the cornea and in the tissue of the iris, and in many cases to discover adhesions between the iris and lens, which cannot be seen by simple inspection. If, however, any doubt remains as to the

* The writer realizes that, from the standpoint of the prevalent school of pathology, it is heterodoxy to express such an opinion as this regarding the genesis of inflammation. He is not without hope, however, that some day he may see a change of opinion upon this point.

existence of iritis after this method of examination has been employed, a weak solution of atropine (gr. ss.–i. to ℥ i.) or of homatropine (gr. iv. to ℥ i.) or euphthalmin (gr. iv.–viij. to ℥ i.) should be dropped into the eye, when, if iritis is present, the pupil will almost certainly dilate in an irregular manner, showing points of adhesion between its margin and the lens capsule.

The character of the vascular injection of the eyeball is not a very trustworthy guide in the differential diagnosis of iritis. When, however, it is most marked around the corneal margin, is of a pinkish rather than a brick-red color, and the vessels involved are for the most part small, and radiate more or less regularly from the margin of the cornea toward the equator of the globe, we may, at least, conclude that some of the structures deeper than the conjunctiva are involved in the inflammatory process, and that the existence of iritis is, at any rate, probable. If, however, the inflammation of the iris is of a severe type, the conjunctival, as well as the pericorneal, vessels will be involved; the injection of the ball will then be diffuse, and even the lids may be hyperæmic and œdematous.

The *treatment* of iritis depends, of course, in a great measure, upon the nature of the cause which has provoked the attack. The indications are to control and overcome the inflammation as quickly as possible, and, by the use of mydriatics, to keep the pupil widely dilated, so that adhesions shall not form between the posterior surface of the iris and the lens capsule. As a rule, constitutional, as well as local, measures are called for. Among the latter the most important are the instillation of a solution of sulphate of atropine, the application of a belladonna or opium lotion, the inunction of the forehead and temples with an ointment of mercury and belladonna, and the local abstraction of blood by leeches or by the artificial leech. Four grains to the ounce (about one per cent.) is the strength of the solution of atropine usually employed. In the different varieties of plastic and suppurative iritis it must be used freely, the frequency of the applications being determined chiefly by the state of the pupil and the amount of ciliary neuralgia and photophobia. When there are recent pupillary adhesions, which we hope to break up (for we can usually accomplish this, unless the bands are firm and broad), an instillation every hour may be required, or even for a short time several instillations an hour may be permissible. Such frequent applications, however, cannot be long continued without the constitutional effects of the drug becoming manifest, and, as cases of marked individual susceptibility to the action of belladonna are occasionally met with, due caution should be exercised in prescribing the use of atropine in this manner. Ordinarily, four to six applications a day are sufficient. In serous iritis atropine is commonly indicated to prevent the possible formation of synechiæ, but it should not be used so frequently or in such strong solutions, since in this affection the pupil generally yields readily to its influence. Moreover, owing to the tendency to increased tension which characterizes this disease, there is danger that a too liberal use of atropine may precipitate a glaucomatous condition.

Occasionally individuals are met with in whom atropine fails to produce a mydriatic effect, and others in whom it greatly irritates the conjunctiva, a few applications producing a conjunctivitis, which may be attended by an eczematous inflammation of the lids and cheek. Under such circumstances hydrobromate of hyoscyamine or sulphate of duboisine may be substituted for atropine. As these mydriatics, especially the latter, are more apt to produce constitutional effects when applied to the eye than atropine, greater caution is required in their use. Two grains to the ounce will usually be a strong enough solution of either of these to employ, and this should not be applied more than three or four times a day.

In many cases of iritis no other local treatment than the employment of a mydriatic is required; but, when the inflammation is of a severe type, the application of three or four leeches to the temple may accomplish great good, and, when there is severe pain, much relief is often experienced from the use of a lotion of opium (ext. opii gr. x.–xv. to aquæ ℥ iv.) or of belladonna (ext. belladonnæ gr. xv. to aquæ ℥ iv.), which should be applied to the closed lids more or less constantly upon a pad of gauze or soft linen. The application in the same way, for half an hour at a time, several times a day, of water as hot as can be borne is also a useful expedient under the same circumstances. In obstinate cases, especially those of syphilitic origin, it is well to supplement the use of constitutional remedies by keeping the forehead and temples constantly anointed with mercurial ointment, to which ext. belladonnæ or ext. opii may be added in the proportion of ʒ i.–ij. to ℥ i. A more cleanly, but perhaps less efficacious, preparation is the oleate of mercury and morphine.

Of constitutional remedies, the most valuable that we possess are mercury, iodide of potassium, and the salicylates. If to this list are added quinine, which is especially useful in suppurative iritis; opium, which seems not only to control the pain, but favorably to influence the inflammation; muriate of pilocarpine, which is useful especially when there is increased tension; and some brisk purgative combination which, as a rule, should contain calomel, it will include all the drugs that are likely to be needed in treating any of the varieties of the disease. A supplemental list of less important, but at times useful, remedies would include arsenic, colchicum, lithia, iron, and the Turkish bath. In acute iritis, whether of specific or non-specific origin, salicylate of sodium or lithium, given in liberal doses (gr. x. to xv. every two or three hours, according to the susceptibility of the patient), is, on the whole, perhaps the most promptly efficacious remedy that we have. In many cases it not only relieves the pain very quickly, but hastens the resolution of the inflammation and promotes the absorption of effused material. The writer believes that this drug has not been widely employed in syphilitic iritis, but it is in such cases that some of the most striking results which he has observed have been obtained. He has also found it useful in serous iritis, and, as might be expected, especially so in iritis dependent upon rheumatism.

In most cases of syphilitic iritis, whether the disease be inherited or acquired, mercury in some form is demanded. It is also our chief reliance in sympathetic iritis, and is more useful than anything else—unless it be iodide of potassium—in the iritis of herpes zoster ophthalmicus and in the other "trophic" nerve varieties. In the acute stage of syphilitic iritis it should be administered liberally, and in such shape as to impress the system promptly. Salivation is to be avoided, but in severe cases we must not stop far short of it. Small doses of calomel, frequently repeated (gr. $\frac{1}{6}$ every hour, or gr. ss. every three hours), supplemented, if necessary, by inunctions of mercurial ointment, or a twenty-per-cent. solution of oleate of mercury, afford the best means of accomplishing the desired result. There seem to be no contraindications to the administration of salicylate of sodium and mercury at the same time, and the writer has obtained good results in this way. Opium may be given if the pain is severe, or if a purgative effect is produced by the mercury. In subacute cases, or when the symptoms are less urgent, biniodide of mercury, in doses varying from gr. $\frac{1}{24}$ to gr. $\frac{1}{12}$, may be given three times a day. This is a very efficacious and convenient method of administering mercury, and salivation is less apt to occur than when calomel is employed. It may be given in tablet triturates or pills, or preferably in solution in water, a small quantity of iodide of potassium being added to render the mercury soluble. When a prolonged course of mercury is required this, or the protoiodide, is decidedly the best form in which to administer it. It is therefore especially useful in the iritis of inherited syphilis, in obstinate cases of serous iritis, and in sympathetic iritis.

Iodide of potassium is valuable in rheumatic iritis, and in the later stages of sympathetic iritis; it may also ad-

vantageously supplement the use of mercury in syphilitic iritis. It may be administered in combination with mercury or by itself. In serous iritis it is the most efficacious remedy that we possess, but its good effects are not always manifest until it is given in large doses.

In suppurative iritis, which, as has been said, usually follows wounds of the eye or operations upon it, and is frequently accompanied by purulent infiltration of the cornea, the free administration of sulphate of quinine offers the best prospect, though not a very promising one, of success. Muriate of pilocarpine, which seems to be as efficacious when administered by the mouth as when introduced into the system by the hypodermatic method, is sometimes useful in cases of serous iritis in which the tension of the globe is high; and in any of the other varieties, if this condition obtains or if there is cloudiness of the vitreous humor, it may be prescribed with advantage. The writer has found it convenient to prescribe it in a solution of the strength of gr. i. to ℨ i. Ten drops of this solution, containing one-sixth of a grain of the salt, is the commencing dose, to be taken by the mouth once a day. According to the effect produced, the dose is increased by adding each day two or three to the number of drops administered. In any severe attack of iritis an active cathartic may be given with advantage at the commencement of the treatment. A very efficacious one is a powder containing from two to five grains of calomel, two grains of scammony, and six of powdered rhubarb, which should be given at bedtime.

When the iritic inflammation is dependent upon a gouty diathesis, colchicum and the preparations of lithia are useful; and in the iritis which sometimes follows malarial attacks, and in that which accompanies ophthalmic shingles, arsenic, in the form of Fowler's solution, may be prescribed with benefit. The daily use of the Turkish bath is commended by Bull as a valuable remedy in arthritic iritis.

In the management of every case of iritis, the question arises whether the patient should be confined to the house during the continuance of the attack. Undoubtedly, in acute cases, and especially when the inflammation is severe, this should be done if practicable. It is very rarely necessary, however, that he should be shut up in a dark room. With a shade and with dark glasses (London-smoke coquilles), he may safely be allowed the freedom of the house. This makes the treatment much less irksome to the patient, and does not seem in the least to retard the cure. In subacute cases, and even in acute cases when there is but little pain or photophobia, the patient need not be confined to the house unless, of course, the weather be unpropitious. Indeed, most patients with iritis are treated successfully as "out-patients," being seen by the medical attendant either at his office or at his hospital clinic.

Surgical interference is rarely required during the active stage of iritis. There are, however, some exceptions to this rule, as, for instance, in serous iritis, when the supervention of glaucomatous symptoms may demand the prompt performance of an iridectomy, or in suppurative iritis, when paracentesis of the cornea may be required for the relief of hypopyon. To remedy the consequences of iritis, however, and to prevent recurrent attacks, operations upon the eye are frequently called for. When, after an attack of iritis, a few slender bands of adhesion between the margin of the pupil and the lens are left, probably no ill consequences will result therefrom, and for such a condition no operation is required. If, however, as happens not infrequently in neglected cases, the margin of the pupil is completely glued to the surface of the lens, an iridectomy should be performed without unnecessary delay, for soon the iris will be bulged forward by the accumulation of fluid behind it, and will undergo atrophy, while at the same time the deeper structures of the eye will suffer from the consequent disturbance of their nutrition. When, though not completely adherent, the margin of the pupil is attached to the lens by several broad bands, an iridectomy may be required, since recurrent attacks of inflammation are not infrequently induced in consequence of the irritation produced by the traction of these bands during the muscular movements of the iris. When the pupil is closed, or is occluded by an organized exudate, an iridectomy is clearly indicated, and may restore almost normal vision to a nearly blind eye by yielding a clear artificial pupil. It is also frequently necessary to perform an iridectomy after the more severe types of iritis, when there is complete adhesion of the iris to the capsule of the lens. Under such circumstances it is more difficult to obtain a clear pupil, since it often happens that the pigment from the posterior surface of the iris remains adherent to the lens, while only the muscular tissue of the iris yields to the traction of the forceps. There is greater danger, too, that the artificial pupil may again become closed or occluded. The operations devised by Streatfeild and Passavant, for breaking adhesions between the margin of the pupil and the capsule of the lens, are not often practised at the present day, though in skilful hands they may at times fulfil a good purpose. In sympathetic iritis the condition of the fellow-eye should, of course, be carefully examined, and if it be blind, or nearly so, and still acting as a source of irritation, it should be enucleated without a moment's unnecessary delay. This will probably not arrest the disease which has become established in the second eye, but it will be likely to influence its progress favorably, and will certainly do no harm.

Samuel Theobald.

IRON.—I. General Medicinal Properties of Compounds of Iron.—All iron preparations capable of absorption are qualified, in some degree, to exert a peculiar influence upon nutrition generally. Given to a person in health, the influence appears to be slight, since the clinical symptoms are insignificant. A rather hard and quickened pulse, a feeling of fulness and tension of the head, and dull pains and discomfort, generally, constitute about all the obvious derangement. When, however, the mineral is administered to a sufferer from *anæmia* of the ordinary type, or from *chlorosis*, much more marked effects follow. The morbid conditions, in these diseases, that are the expression of deficient hæmoglobin tend to subside with greater or less rapidity; the pale, waxy skin becomes rosy, the flabby tissues become firm, weight increases, appetite is gained, and in every way the invalid improves in health and strength. In pernicious anæmia, however, iron is commonly without effect.

The clinical results thus seen to follow the medicinal giving of iron, both in health and disease, obviously suggest that the action of the drug is to determine an increase in the quantity of hæmoglobin present in the circulation, either by enrichment in hæmoglobin of the red blood corpuscles or by a quickening in the rate of evolution of these bodies, or possibly by both means combined. Exact observations on the blood of anæmics and chlorotics during a course of iron show that the medicine is indeed capable of producing both the effects described.[1] With large doses, the tendency is first to increase the hæmoglobin richness of the red corpuscles, and later the number of the globules; with small doses, to reverse this order of proceeding. Probably, in either case, the essential action of the iron is to determine hæmoglobin enrichment, the effect on rate of corpuscular evolution being a secondary consequence. How iron accomplishes this feat is, as usual in the matter of the action of a medicine, entirely unknown. The original idea was the simple one that since in chlorosis there is a deficiency of hæmoglobin, medicinal iron is absorbed and appropriated to make good the deficit, and that is the whole of the story. Later, however, it was observed that even when iron is given in quantities enormously in excess of physiological needs, the normal trace of iron occurring in the urine is not increased. Accordingly, it was argued that no excretion by the kidneys of adventitious iron must mean none to excrete, and therefore that medicinal iron is not absorbed. So came about theories of the action of iron in chlorosis based on the different chemical behavior of iron when in ordinary saline combination, on the one hand

("inorganic" iron, so called), and, on the other, in that peculiar combination in which the metal occurs as a constituent of the animal body, as in hæmoglobin ("organic" iron). "Inorganic" iron is precipitated from solutions by alkaline sulphides, but "organic" iron resists such attack unless the sulphides are present in excess. According to the theory, therefore, ordinary medicinal iron, being, as it is, "inorganic" iron, is all precipitated by the sulphides of the alimentary canal, and consequently is not absorbed at all. "Inorganic" iron, then, can cure chlorosis indirectly only, by promoting in some way assimilation of the "organic" iron of the subject's dietary. And two such ways have been assumed: the one, by simple improvement of digestion generally, through local action of medicinal iron upon the intestine, and the other by vicarious sacrifice of the "inorganic" iron itself as follows: It is assumed (Bunge) that in chlorosis there is an excess of sulphides in the *primæ viæ* whereby even the "organic" iron of the foods is attacked and precipitated. By reason of such precipitation, then, the food iron is not absorbed in full, and the chlorotic condition results. But if now a chalybeate is taken, the sulphides seize upon such "inorganic" iron in preference to the "organic" food iron, and so the latter is saved for absorption.

But to this theory of the non-absorption of "inorganic" iron there are fatal objections. First, under the theory, anything else than iron equally effective either to improve digestion or to precipitate sulphides ought to be just as good as iron at curing chlorosis, whereas such is distinctly not the case. Secondly, iron should be inoperative if introduced in the form of sulphide into the intestine; but again the fact is the other way. Thirdly and conclusively, absorption of "inorganic" iron introduced into the alimentary canal has positively been demonstrated, and in different ways, by a number of experimenters upon animals.

The non-excretion by the kidneys of ingested iron is very simply explained by the fact that, as in the case of other heavy metals, iron is excreted mainly by the *intestines.* The history of iron in the animal system is undoubtedly this: It is absorbable from the intestines, whether originally presented as "inorganic" or "organic" iron; and, after absorption, so much as may be wanted for physiological needs is stored away, mainly in the liver and spleen, thence to be put forth, as may be required, in the form of "organic" iron. What is absorbed in excess of needs is excreted, but this excretion, as just said, is principally by the same avenue as that of entry into the system, namely, by the intestines.

It is unfortunate that the theory of non-absorption of "inorganic" iron should have gained such vogue as has been the case. For the result has been, on the one hand, undeservedly to discredit the ordinary chalybeates, and, on the other, to flood the market with new and expensive preparations purporting to offer iron in a condition especially fit for assimilation, when, as a matter of fact, the standard and cheap preparations of the Pharmacopœia are just as good.

Being itself a normal constitutent of the animal substance, iron is non-poisonous so far as constitutional effect is concerned in any ordinary dosage. Locally, however, there is the widest possible difference in the action of the different iron preparations, some being absolutely bland, while others are irritant or astringent and styptic.

The character of an iron compound, *in re* astringency or irritation, is determined in part by the solubility of the salt, and in part by the character of the salt's acid radical. For, of course, in the first place, all compounds insoluble, or but sparingly soluble, in fluids of aqueous basis are locally bland, so that metallic iron, ferrous carbonate, and ferric hydroxide, hypophosphite, and valerianate are bland irrespective of the quality of their several acids. Of aqueously soluble compounds, those that are salts of the so-called organic acids—lactic, acetic, citric, and tartaric—and the mixed salts of the United States Pharmacopœia passing under the names of "phosphate" and "pyrophosphate," are comparatively bland—the citrates, tartrates, and phosphates being quite so, the lactate and acetate not so purely. The salts of the strong so-called mineral acids are in varying degree astringent, irritant, or both, as follows: Powerfully styptic, are *ferric chloride, ferric nitrate,* and the two grades of *ferric sulphate,* normal and basic ("tersulphate" and "subsulphate," respectively); powerfully astringent, but with proportionately less coagulating faculty, *ferrous sulphate* ("green vitriol," "sulphate of iron") and *ammonio-ferric sulphate* ("iron-alum"); decidedly irritant, but not distinctively astringent, *ferrous iodide.* True "organic" iron is always bland.

Clinically, the respective local effects of the two broad groups thus defined are as follows: The astringent or irritant compounds have a harsh, *puckery,* generally sour and disagreeably inky taste, and, upon frequent taking, tend to blacken and even to corrode the teeth. The blackening is removable by a tooth-brush, but the corrosion is, of course, a serious matter, and necessitates the clinical rule to order solutions of astringent chalybeates to be taken through a glass tube set far back over the tongue, and the mouth to be well rinsed after the swallowing. Upon the healthy stomach, small doses of the astringents, in common with most other not over-noxious irritants, tend to excite appetite and quicken digestion, but large doses to derange. Upon a stomach the seat of a decided catarrh—as is unfortunately often the case in the very circumstance of anæmia calling for chalybeate medication—even comparatively small doses act so unkindly that the astringents have to be set aside and a bland chalybeate substituted. Upon the bowels there is a strong tendency to constipate—so strong that in a considerable course of medication with an astringent iron salt the condition of the bowels must carefully be watched and regulated. In overdose the astringents are irritant poisons—fatal, it may be, in sufficient volume and concentration of solution.

Of these various effects there is seen but a shadow, or not even that, among the bland preparations. Some of the soluble ones may taste a little inky and blacken the teeth, but they do not corrode. Some tendency to constipation may be noted, but far less in degree than with the astringent compounds; while severe irritation of the stomach, poisoning, and local stypticity are entirely wanting. Chalybeates of the bland group that are insoluble of course have practically no taste and absolutely no astringency, and do not blacken the teeth. After being swallowed such preparations are attacked by the free acid of the gastric juice, and being changed thereby to soluble form, are capable of absorption, and thus of full chalybeate constitutional power.

All chalybeates, finally, bland and astringent, blacken the stools by their presence therein in the condition of tannate or sulphide. These derived salts thus discharged in the *dejecta* may, in part, represent a certain portion of the iron dose that has entered the blood, and, after a due career in the circulation, has been excreted by the bowels, and in part they may be, and undoubtedly are, the simple excess of dose that, unabsorbed, has been passed along the alimentary canal to the rectum. Of course, the blackening of the stools is of no consequence; the only point is that the patient should be forewarned of the circumstance, lest the unusual color of the fæces excite alarm.

Therapeutically, the two main applications of iron compounds are their internal administration for the cure of *anæmia*—in which case the medicine is referred to as a *chalybeate*—and the local use of the ferric styptics for the control of hemorrhage. There are, however, certain special applications of certain compounds, which will be detailed in due place.

II. Medicinal Preparations of Iron.—The preparations of iron official in the United States Pharmacopœia are derived from the following chemical conditions of the metal: 1. The metal uncombined, in state of powder. 2. The metal in ferrous combination, as, severally, *carbonate, lactate, sulphate,* and *iodide.* 3. The metal in ferric combination, as, severally, *hydroxide* ("hydrated oxide"), *acetate, citrate, ammonio-citrate, potassio-tartrate, am-*

monio-tartrate, sodio-phosphate ("phosphate"), *sodio-pyrophosphate* ("pyrophosphate"), *hypophosphite, valerianate, chloride, basic sulphate* ("subsulphate"), *normal sulphate* ("tersulphate"), *ammonio-sulphate,* and *nitrate.* These several compounds will be discussed seriatim, together with the preparations of the United States Pharmacopœia derived from each.

Iron Uncombined.

Metallic iron, in the condition of fine powder, is a valuable chalybeate of the bland variety, characterized by richness, tastelessness, and perfect blandness, combined with promptness and efficiency. Because of these qualities metallic iron is especially serviceable in the case of children or of subjects of any age with sensitive stomachs or squeamish palates. Iron in powder is easily obtainable by reducing ferric oxide, heated in a reduction tube, by a stream of hydrogen gas. The product is official in the United States Pharmacopœia under the title *Ferrum Reductum,* Reduced Iron, also known as *Quevenne's iron,* and *iron by hydrogen.* Reduced iron, pulverulent at the forming, is subjected to further fine pulverization, and then appears as a soft, smooth, heavy powder of a lustreless, blackish-gray hue. It is, of course, insoluble in neutral fluids, such as water, alcohol, or glycerin, but it dissolves, with effervescence of hydrogen, in dilute acids, by entering into saline combination therewith. Its medicinal activity is determined by this reaction, the acids of the gastric juice acting as solvents. Reduced iron should be kept, well dried, in a tightly stoppered bottle, in order to prevent oxidation, a reaction to which the preparation is very prone. Purity is important, since impure specimens give rise to eructations of disagreeable gas after taking. A good sample is a gray-black, and not deep black, and on treatment with dilute sulphuric acid, warmed, dissolves wholly, and the hydrogen gas evolved is nearly without odor. Black specimens, effervescing but slightly with dilute acids, are spurious.

The dose of reduced iron ranges from 0.20 to 0.40 gm. (gr. iij. to vi.), given three times a day. Being tasteless, the preparation may be given, even to children, in powder, or it may be ordered in pill, or, convenient for children, in chocolate lozenge. The administration should be at or about meal-times, so as to secure the prerequisite of presence of acid gastric juice; and if digestion be sluggish, it is well even to add an acid, for which purpose the innocent acid of lemonade is perfectly efficient.

Ferrous Carbonate: $FeCO_3$.

Ferrous carbonate, also insoluble, closely resembles reduced iron in combining perfect blandness with efficiency. But since the salt undergoes rapid spontaneous decomposition, it is available for prescribing only in certain pharmaceutical preparations wherein decomposition is prevented by the presence of sugar. These preparations, in the United States Pharmacopœia, are as follows:

Ferri Carbonas Saccharatus, Saccharated Ferrous Carbonate. A solution of ferrous sulphate is added to one of acid sodium carbonate; ferrous carbonate forms as a pale, bluish-white precipitate, which is collected, washed, drained, and, while still moist, mixed with sugar. Then the mixture is dried over a water-bath, and the product is pulverized. Such powder is to be kept in small bulk, in tightly stoppered bottles. Saccharated carbonate of iron thus made is a dull, greenish-gray powder of a saccharine and faintly ferruginous taste. It is neutral in reaction; in water only the sugar of its composition dissolves, but in dilute acids the entire powder disappears by chemical conversion of the iron salt, the reaction attended by copious evolution of carbon dioxide. The dose is from 0.30 to 2 gm. (gr. v. to xxx.), three times a day, given in powder or pill. But if the pill form be desired, the following official preparations are better:

Massa Ferri Carbonatis, Mass of Ferrous Carbonate, known also as *Vallet's mass,* or *Vallet's ferruginous pills.* Ferrous carbonate is precipitated as in making the foregoing preparation, but now from a syrupy instead of from a simple aqueous solution of ferrous sulphate, and syrup instead of plain water is used for the washings. The protective influence of sugar is thus utilized from the start, with the result of securing a quite perfect preservation of the ferrous salt. After collection, the precipitate of the carbonate is incorporated with honey and sugar, and the mixture evaporated to a certain weight. A greenish-black, soft, pilular mass results. The mass contains about half its weight of the iron salt, and may be given in doses, thrice daily, of from 0.20 to 0.30 gm. (gr. iij. to v.), of course in pill.

Pilulæ Ferri Carbonatis, Pills of Ferrous Carbonate, "Ferruginous Pills," "Chalybeate Pills," "Blaud's Pills." These pills are an imitation of the famous French "*Blaud's ferruginous pills,*" and are compounded of ferrous sulphate, potassium carbonate, sugar, tragacanth, and marshmallow, made into pilular consistence with a few drops of glycerin and water. The usual double decomposition occurs between the ferrous sulphate and the alkaline carbonate, with the production of ferrous carbonate. The pills should be made freshly when wanted, and from two to six may be given at a dose.

Ferrous carbonate is the salt of iron present in the following preparation of the United States Pharmacopœia, designed to afford the association of iron with myrrh for prescription to women, when anæmia is complicated with menstrual debility or an hysterical tendency:

Mistura Ferri Composita, Compound Iron Mixture, "Griffith's Mixture." In this mixture, rose-water, flavored with spirit of lavender, and charged with the necessary sugar, holds in suspension myrrh and ferrous carbonate, the latter precipitated by mixture of ferrous sulphate and potassium carbonate. The mixture, despite the sugar present, does not keep well, and should be made fresh on prescription. From 30 to 60 gm. (fl. ℥ i. to ij.) may be given three times a day.

Lastly, ferrous carbonate is the condition in which iron exists ordinarily in chalybeate waters, the salt being held in solution by the excess of carbonic acid with which the waters are charged. The rust-colored deposit which these waters yield is due to the ferric hydroxide resulting from the usual spontaneous decomposition of the carbonate.

Ferrous Lactate: $Fe(C_3H_5O_3)_2.3H_2O$.

Ferrous lactate was proposed as a medicine from theoretical considerations. On the assumption that many chalybeates become lactates in the stomach through the action of lactic acid in the gastric juice, it was thought that the lactate itself would prove exceptionally easy and quick of absorption. Clinical experience, however, fails to show any decided superiority of the salt. Ferrous lactate is official in the United States Pharmacopœia under the title *Ferri Lactas,* Ferrous Lactate, and presents itself in dingy-green crystalline grains or crusts, sparingly soluble only in cold water (in forty parts at 15° C.). It is a fairly good chalybeate, but is a trifle irritant as compared with reduced iron or the carbonate. It may be given in doses of from 0.12 to 0.20 gm. (gr. ij. to iij.) in pill or mixture.

Ferrous lactate is the salt of iron used in preparing the United States Pharmacopœia official syrup entitled *Syrupus Hypophosphitum cum Ferro,* Syrup of Hypophosphites with Iron. This preparation is simply the syrup of hypophosphites (see Hypophosphites), holding one per cent., each, of ferrous lactate and potassium citrate in solution. The lactate is selected for this application solely for the chemical reason that it does not form a precipitate with the hypophosphites. The syrup may be given in teaspoonful doses three times daily. It should be made fresh when wanted.

Ferrous Sulphate: $FeSO_4.7H_2O$.

Ferrous sulphate is the salt so well known as *greeen vitriol,* and also in the impure state as *copperas.* Medicinally, it is of triple interest, being efficient as a chalybeate, an astringent, and a disinfectant. The salt can be ob-

tained in the condition of large crystals, crystalline grains, and in the powder that results from depriving the crystals, by efflorescence and heat, of the greater part (six molecules) of their water of crystallization. All three conditions are official in the United States Pharmacopœia, the crystalline being entitled *Ferri Sulphas*, Ferrous Sulphate; the granular, *Ferri Sulphas Granulatus*, Granulated Ferrous Sulphate; and the powder of efflorescence, *Ferri Sulphas Exsiccatus*, Dried Ferrous Sulphate. The official crystals represent a pure form of the article, such as alone should be used if intended for internal giving. The crystals are large monoclinic prisms of a pale bluish-green color, and effloresce slowly on exposure. The crystalline grains—the "granulated sulphate" of the United States Pharmacopœia—result from pouring a solution of ferrous sulphate slowly, with constant stirring, into alcohol. The salt then, being insoluble in alcohol, separates in a crystalline powder, which powder is of the same tint as the ordinary crystals, and also effloresces in dry air. The third, the "dried" form, is obtained by heating the previously effloresced salt so long as it yields water of crystallization, and then pulverizing. It is a fine, grayish-white powder, of which a little over three parts are the equivalent in chalybeate value of five of the crystals.

Ferrous sulphate in all its forms dissolves in water, the two varieties of crystals fully and freely, the effloresced powder more slowly and with a small residue. In alcohol it is insoluble. The salt, although not truly styptic, is strongly astringent and is capable, in overdose, of producing irritant poisoning. Medicinally it can be used as a chalybeate, and is important in being the only decidedly astringent chalybeate that can conveniently be given in pill form. When prescribed internally, therefore, it is commonly in such form, and for this the dried sulphate should invariably be selected, since the crystals, by efflorescence, would tend to disintegrate a pill mass. The dose is from 0.05 to 0.10 gm. (about gr. i. to ij.), three times a day. If ordered in solution (in which condition, however, ferrous sulphate presents no particular reason for selection), one of the crystalline forms should be prescribed, and care should be taken to avoid in the solution any of the many chemical incompatibles of the salt. These are catalogued as the alkalies and their carbonates, soaps, lime water, calcic and basic chlorides, sodium borate and phosphate, silver nitrate, and lead acetate and subacetate.

If, furthermore, the iron sulphate contain any of the hydroxide, as it is very apt to do, anything charged with tannic or gallic acid, as are many vegetable infusions, will make ink on admixture. This reaction, however, can be prevented by the addition of a small quantity of any of the pharmacopœial dilute mineral acids—an addition rarely objectionable under the circumstances in which the chalybeate is likely to be prescribed. Ten drops of diluted sulphuric acid to a 100 c.c. bottleful (about four fluidounces) of a half-per-cent. solution of ferrous sulphate and tannic acid has been found competent to prevent the usual precipitation.

Ferrous sulphate can be used locally for the usual purposes of the mineral astringents, but is rarely so employed, since it presents no advantage over the time-honored salts of silver, copper, zinc, etc. If used, it is to be applied in solution, whereof the strength will range from one-fifth per cent. to about two per cent., according to the sensitiveness of the part; or it may be made into ointment of from one per cent. to three per cent. in strength.

Thirdly, ferrous sulphate has an old-time reputation as a so-called "disinfectant." Recent exact experiments have shown that the salt may fail utterly as a germicide, although capable, in 0.5-per-cent. solution, to inhibit temporarily the vital activity of certain microzymes. Limitations in the employment are that the salt, not being volatile, is useless for aerial disinfection, and that, because of its staining, it must not be employed to treat textile fabrics, floors, or walls. But for bed-pans, close stools, sinks, drains, cesspools, privies, etc., ferrous sulphate is unobjectionable, and has the positive advantages of being cheap and odorless. For application, the very cheap commercial copperas answers just as well as the pure pharmacopœial salt. A handful of the crystals may be put into a bed-pan or close stool that is to receive offensive or contagious discharges, or, where a solution is more convenient, this may be made of about fifteen per cent. strength, and should be used liberally. When large quantities are wanted, a convenient plan is to suspend a basket holding about sixty pounds of copperas in a barrel of water, from which barrel the solution is dipped out as wanted.

Lastly, concerning ferrous sulphate, it is the iron salt present in the official preparation of the United States Pharmacopœia entitled *Pilulæ Aloës et Ferri*, Pills of Aloes and Iron. (This preparation, being rather one of aloes than of iron, has been discussed under *Aloes*, which see.)

Ferrous Iodide: FeI_2.

In the medicinal virtues of ferrous iodide, the iodine, because of its small actual quantity in allowable doses of the compound, plays a very subordinate part. The salt is therefore essentially a chalybeate, with but a dash, so to speak, of iodine virtues. Ferrous iodide is irritant, without being astringent, and is somewhat remarkable for a tendency to relax rather than to constipate the bowels. It is sometimes also diuretic. As a chalybeate it is efficient, and is most commonly selected in cases in which the action of iodine is desired along with that of iron—this rather on theoretical grounds. Chemically, ferrous iodide, like the carbonate, is hopelessly unstable, so that the prescriber is again restricted to special pharmaceutical forms for the administration. These in the United States Pharmacopœia are as follows:

Ferri Iodidum Saccharatum, Saccharated Ferrous Iodide. Iron wire and iodine are brought together in the presence of water; direct union of the elements results, and the ferrous iodide dissolves as it forms in the water. After the reaction is complete the solution is filtered into a vessel holding an appropriate quantity of sugar of milk. The whole is then evaporated to dryness, mixed with an additional portion of sugar of milk, to which also a little reduced iron is added, and the final product pulverized. The preparation is then to be put at once into small, well-dried bottles, tightly stoppered, and is to be kept in a cool and dark place. This saccharated iodide is a grayish powder, very hygroscopic, because of a strong deliquescent tendency of ferrous iodide, is of a sweetish ferruginous taste, and is wholly soluble in water (in seven parts at 15° C.). It is only partially soluble in alcohol. It contains twenty per cent. of ferrous iodide, and may be administered in doses, thrice daily, of from 0.12 to 0.30 gm. (gr. ij. to v.).

Syrupus Ferri Iodidi, Syrup of Ferrous Iodide. Ferrous iodide is formed in solution exactly as in the foregoing instance, and the solution, with proper manipulations of heating and filtering, is mixed with syrup, of the proper quantity to make the product contain ten per cent. of ferrous iodide. When freshly made this syrup is of a clear, pale-green color, is odorless, and of a combined sweet and harshly ferruginous taste. Despite the sugar of its composition, it is very prone to change, in which case the color passes from green to yellow, or even brown. This change occurs mainly through exposure to the oxygen of the atmosphere, the iodide being in part decomposed, the iron suffering oxidation, and the iodine being set free. To prevent change the syrup should be kept in small vials, well stoppered, fully filled, and exposed to diffused daylight. If discoloration have taken place, the original clearness and color can be reproduced by treating the syrup with sodium hyposulphite. A four-per-cent. solution of this salt in water is made, of which 1 c.c. (♏ xv.) may be added to half a litre (one pint) of discolored syrup. If the discoloration have proceeded to a distinct brown, the dose of hyposulphite solution must be increased. Syrup of ferrous iodide is a very

frequently used and thoroughly efficient chalybeate. It is given in doses, thrice daily, of from 0.50 to 2 gm. (about from ♏ vi. to xxx.), which doses, because of the extreme chemical vulnerability of the preparation, should never be made constituent to a composite prescription, but always given alone, simply well diluted with water, and even this dilution done only at the time of administration. The medicine, furthermore, being very liable to attack the teeth, should be taken through a glass tube and the mouth well rinsed after each dose.

Pilulæ Ferri Iodidi, Pills of Ferrous Iodide. Iodine and reduced iron, the latter in slight excess, are made to react in presence of water, until all the iodine is converted into iodide. Then certain proportions of licorice, sugar, extract of licorice, and gum arabic are added, and the mixture is evaporated to pilular consistence. The mass is then cut up into pills, and the individual pills are coated with balsam of tolu dissolved in a little ether, to protect them from the action of the atmosphere. These pills are in imitation of the so-called *Blancard's pills*, and are an efficient representative of the virtues of ferrous iodide. Each pill contains about 0.065 gm. (gr. i.) of ferrous iodide, and 0.012 gm. (gr. $\frac{1}{5}$) of reduced iron, and from one to two pills constitute a dose.

Ferric Hydroxide ("Hydrated Oxide"): $Fe_2(OH)_6$.

Ferric hydroxide is peculiar among the medicinal *ferric* compounds in being insoluble in water. Furthermore, it seems to resist obstinately the solvent powers of the alimentary juices, for when taken internally, even in quite large quantities, in anæmia, it produces very little effect. Locally, as might be inferred, it is absolutely bland. Because of its feebleness, the hydroxide is practially useless as a chalybeate, and its medicinal value is solely because of a peculiar chemical reaction it affords with arsenical compounds, whereby it becomes a possible chemical antidote in poisoning by arsenicals. The reaction is that ferric hydroxide, when freshly made and still moist, attacks arsenical compounds in solution, and forms out of them a ferrous arsenate which is insoluble, and therefore inert. So long as the arsenical is in solid condition there is no reaction, but as fast as solution takes place the hydroxide, if upon the ground, attacks the dissolved compound, as described. For the reaction in full, the estimate is that twelve parts of antidote are needed for each part of poison; but since the hydroxide is harmless, the practice is to give it freely and frequently so long as the symptoms of poisoning persist.

Ferric hydroxide is easily obtainable by treating with an alkali a solution of a ferric salt. The salt is decomposed, its acid radical going over to the alkali, and its basic precipitating as ferric hydroxide. The precipitate thus occurring is brick-red, pulpy, tasteless, and perfectly bland. Washed and mixed with the proper amount of water, it forms a magma, in which condition it is given in teaspoonful doses every five minutes, in application as antidote to arsenic. Two formulæ for procuring the hydroxide are authorized by the United States Pharmacopœia, and since the physician may need himself to prepare the antidote, the formulæ are here reproduced in full:

Ferri Oxidum Hydratum, Ferric Hydrate. "Solution of ferric sulphate, 100 c.c.; ammonia water, 110 c.c.; water, a sufficient quantity. To the ammonia water, previously diluted with 250 c.c. of cold water, add, under constant stirring, the solution of ferric sulphate, previously diluted with 1,000 c.c. of cold water. As soon as the precipitate has subsided, draw off the clear liquid by means of a siphon, then mix the precipitate intimately with about 1,000 c.c. of cold water, again draw off the clear liquid after subsidence of the precipitate, and repeat this operation until a portion of the decanted liquid gives not more than a slight cloudiness with barium chloride test solution.* Finally, transfer the precipitate to a wet muslin strainer, and, after it has drained, mix it with sufficient cold water to make the mixture weigh 250 gm.

* An aqueous solution of the salt, 12.2 per cent. in strength.

"When ferric hydrate is to be made in haste, for use as an antidote, the washing may be performed more quickly, though less perfectly, by transferring the precipitate at once to a wet muslin strainer, pressing forcibly with the hands, until no more liquid passes, and then adding enough water to make the whole weigh about 250 gm. NOTE.—The ingredients for preparing ferric hydrate as an antidote should always be kept on hand in bottles containing, respectively, 200 c.c. of the solution of ferric sulphate, and 220 c.c. of ammonia water" (U. S. P.).

The objection to this process is the time consumed in the washing and straining, and accordingly the following preparation is offered, in which the hydroxide is precipitated by magnesia instead of ammonia, and the excess of magnesia and the magnesium sulphate resulting from the reaction with the iron sulphate are permitted to remain, since they are harmless. Accordingly the preparation is ready for use at once:

Ferri Oxidum Hydratum cum Magnesia, Ferric Hydrate with Magnesia. "Solution of ferric sulphate, 50 c.c.; magnesia, 10 gm.; water, a sufficient quantity. Mix the solution of ferric sulphate with 100 c.c. of water, and keep the liquid in a large, well-stoppered bottle. Rub the magnesia with cold water to a smooth and thin mixture, transfer this to a bottle capable of holding about 1,000 c.c., and fill it with water to about three-fourths of its capacity. When the preparation is wanted for use, shake the magnesia mixture to a homogeneous thin magma, gradually add to it the iron solution, and shake them together until a uniform, smooth mixture results. NOTE.—The diluted solution of ferric sulphate, and the mixture of magnesia with water, should always be kept on hand, ready for immediate use" (U. S. P.).

Ferric hydroxide, dried, is the compound of iron contained in the two following official preparations of the United States Pharmacopœia:

Trochisci Ferri, Troches of Iron. These are compounded of ferric hydroxide, dried by heat; vanilla, sugar, and mucilage of tragacanth. Each lozenge contains 0.30 gm. (gr. v.) of dried hydroxide.

Emplastrum Ferri, Iron Plaster. This plaster contains nine per cent. of dried ferric hydroxide in admixture with lead plaster, olive oil, and Burgundy pitch. It is commonly known as *strengthening plaster*, but, of course, any specific virtues due to the iron are imaginary.

Of the next following salts of iron, the acetate and the various citrates, tartrates, and phosphates have so many features in common as to constitute a distinct subclass. These salts are all soluble in water, bland in action, and of little taste; they decompose spontaneously in aqueous solution, and, obtained in solid form by evaporation of such solution, present the appearance of thin, shining scales, looking like broken bits of thin, colored gelatin. They are valuable, medicinally, as affording bland chalybeates whose solubility and freedom from taste enable them to be given without objection in fluid form. They are common as the iron basis of many fancy fluid pharmaceutical preparations. They should be kept in well-stoppered bottles, protected from light.

Ferric Acetate: $Fe_2(C_2H_3O_2)_6$.

Since acetic acid is a pretty sharp acid, ferric acetate has a sharp quality, and, accordingly, is not so purely bland as are the citrates and tartrates. It is an excellent chalybeate of its type, and is official in the United States Pharmacopœia, not in solid form, but in the two following pharmaceutical preparations only:

Liquor Ferri Acetatis, Solution of Ferric Acetate. "An aqueous solution of ferric acetate, containing about thirty-one per cent. of the anhydrous salt" (U. S. P.). It is made by saturating glacial acetic acid with freshly precipitated ferric hydroxide, and bringing the solution to standard strength by the addition of water. Like most of the solutions of the present series of compounds, this preparation is a deep reddish-brown fluid of mild ferruginous flavor only. It may be given as a medicine in

doses of from 0.12 to 0.65 gm. (♏ ij. to x.), diluted with at least an equal bulk of aqueous or syrupy vehicle. It should be kept in well-stoppered bottles and in a cool place away from light.

Liquor Ferri et Ammonii Acetatis, Solution of Iron and Ammonium Acetate, Basham's Mixture. This solution is an elegant elixir, containing a weak charge of iron in condition of acetate. It is compounded of tincture of chloride of iron (two per cent.), diluted acetic acid, solution of ammonium acetate, aromatic elixir, glycerin, and water. By reaction the iron becomes the acetate, and part of the ammonium acetate becomes ammonium chloride, but the greater part of the ammonium salt remains unchanged. The preparation is a beautifully clear, reddish solution of agreeable elixir taste, with scarcely a trace of ferruginous flavor. For its strength it is efficient, and may be given in doses of a tablespooonful three or four times a day. It decomposes spontaneously on keeping for any length of time, and accordingly should be freshly made, when wanted.

Ferric Citrate: $Fe_2(C_6H_5O_7)_2.6H_2O$.

Normal ferric citrate is peculiar, among the group under consideration, in that it dissolves quite slowly, although fully, in cold water, and when once in solution is comparatively stable. Because of slow solubility it is peculiarly fitted for prescription in pill. The salt is official as follows:

Liquor Ferri Citratis, Solution of Ferric Citrate. "An aqueous solution of ferric citrate, corresponding to about 7.5 per cent. of metallic iron" (U. S. P.). Fresh and moist ferric hydroxide is mixed with citric acid, and the mixture heated, with stirring, until a solution results. Such solution is then evaporated at a gentle heat until reduced to standard strength. In this procedure ferric citrate forms by direct union of the radicals, and dissolves in the water entangled in the magma of the hydroxide. This solution may be used medicinally, given in doses of about 0.65 gm. (♏ x.), corresponding very nearly to 0.32 gm. (gr. v.) of the scaled preparation next to be described, but its essential purpose is to afford this same preparation, as follows:

Ferri Citras, Ferric Citrate. The above solution is evaporated, at a temperature not exceeding 60° C. (140° F.), to the consistence of syrup, and the syrupy fluid is then spread upon plates of glass and allowed to dry. A film of solid matter results, which breaks up into transparent garnet-red "scales," constituting the preparation in question. Such scales have the properties of ferric citrate as already described, and may be given in doses, three times daily, of 0.30 gm. (about gr. v.), being specially selected for administration in pill.

Ferri et Quininæ Citras, Iron and Quinine Citrate. The above scaled preparation and quinine—the alkaloid, dried till it ceases to lose weight—in the proportion of eighty-five of the former to twelve of the latter, are dissolved together in water, with the addition of a little free citric acid, and the solution is then evaporated for the yielding of scales, as described in the foregoing example. The product is in transparent, reddish or yellowish-brown scales, bitter and mildly ferruginous in taste, and dissolving, as does the simple citrate, completely but slowly in cold water. The scales should be kept in the dark, in well-stoppered bottles. They represent the ingredients probably in simple mixture only. The preparation affords a means of giving a chalybeate in conjunction with quinine; convenient where the indication fits the one proportion between the constituents which these scales provide, but otherwise not. The dose averages 0.30 gm. (about gr. v.), representing rather less than 0.06 gm. (gr. i.) of quinine, given, by natural selection, in pill.

Ammonio-ferric Citrate.

If the official solution of citrate of iron be charged with one-fourth of its weight of water of ammonia, and the mixture then evaporated in the usual manner (see Ferri Citras, above), scales will be obtained identical in characteristics with the scales of the citrate already described, except that they dissolve rapidly instead of slowly in cold water. Such scales are regarded as representing a double citrate of the two bases, but the exact chemical constitution, as is the case with all the composite scale preparations, is difficult to determine. The preparation is official as *Ferri et Ammonii Citras*, Citrate of Iron and Ammonium, and is medicinally convenient as a substitute for the simple citrate when the chalybeate is desired in solution. Pharmaceutically, it is the basis of the following:

Vinum Ferri Citratis, Wine of Ferric Citrate. Four per cent. of the ammonio-citrate scales is dissolved in a mixture of tincture of sweet orange-peel, syrup, and white wine. This wine makes a weak chalybeate elixir, to be given in doses of a teaspoonful, representing about 0.20 gm. (gr. iij.) of the iron compound.

Ferri et Strychninæ Citras, Iron and Strychnine Citrate. Scales of the ammonio-citrate are dissolved in water, and the solution is mixed with a solution of strychnine citrate, made by adding strychnine and citric acid together to water. From the mixed solution scales are obtained in the usual way. The composite scales thus derived are indistinguishable in appearance and solubility from those of the plain ammonio-citrate, but declare themselves by their bitter taste. They contain two per cent. of the citrate of strychnine, equivalent to one per cent. of the alkaloid itself. The average dose is about 0.30 gm. (about gr. v.), representing 0.003 gm. of strychnine (gr. $\frac{1}{20}$), given in pill, or, having due regard to the bitterness, in solution.

The ammonio-citrate also occurs in the following preparations:

Ferri et Quininæ Citras Solubilis, Soluble Iron and Quinine Citrate. This preparation is made of the same ingredients and in the same way as the simple iron and quinine citrate, but, by the addition of ammonia water to the solution before evaporation, the ammonio-citrate forms, and the resulting scales are rapidly and completely soluble in cold water. This preparation, accordingly, is to be selected when the double citrate is wanted in solution instead of in pill. The scales are of a greenish-yellow color.

Vinum Ferri Amarum, Bitter Wine of Iron. This wine is compounded of five per cent. of the foregoing soluble iron and quinine citrate, made into an elixir with tincture of sweet orange peel, syrup, and white wine. It is given in teaspoonful doses.

Potassio-ferric Tartrate.

Although not selected for the making of fancy preparations, the potassio-tartrate of iron is a valuable chalybeate, being of little taste, perfectly bland, and, perhaps because of the potassium tartrate of its composition, less disposed to constipate than the average of iron salts. The salt is official under the title of *Ferri et Potassii Tartras*, Iron and Potassium Tartrate, as a scale preparation, gotten in the usual way (see *Ferri Citras*, above), from a solution resulting from admixture, in water, of fresh ferric hydroxide and acid postassium tartrate ("bitartrate"). The scales are garnet-red, similar in appearance to the scales of the citrate, and probably represent a double tartrate of the contained bases. The preparation is so bland that it may be given in comparatively large doses, ranging from 0.65 to 2 gm. (gr. x. to xxx.), most naturally in solution.

Ammonio-ferric Tartrate.

Ammonio-ferric tartrate is substantially a duplicate of the potassio-tartrate just described. It occurs in scales, derived from a solution wherein the salt is made by a process analogous to the foregoing. The preparation is official as *Ferri et Ammonii Tartras*, Iron and Ammonium Tartrate, and in appearance, solubility, and dose conforms to the example of the potassio-tartrate.

(Sodio-) Ferric Phosphate

Under the title *Ferri Phosphas Solubilis*, Soluble Ferric Phosphate, the United States Pharmacopœia makes official a scale preparation containing sodio-ferric phosphate and obtained out of a solution in which ferric citrate has been decomposed by the addition of uneffloresced sodium phosphate. The preparation must not be confounded with a formerly official "phosphate," which consisted of the slate-colored, insoluble ferroso-ferric phosphate that precipitates from reaction of ferrous sulphate and sodium phosphate in solution. The scales of the present preparation differ from those of the citrates and tartrates in being of a bright-green color instead of garnet-red. They are bland, of little taste, and make an excellent chalybeate of their kind. Dose, from 0.30 to 0.65 gm. (about from gr. v. to x.), in pill or solution.

Compounded from these scales and from quinine, strychnine, and phosphoric acid is an official syrup entitled *Syrupus Ferri, Quininæ, et Strychninæ Phosphatum*, Syrup of the Phosphates of Iron, Quinine, and Strychnine. The dose is limited, by the presence of strychnine, to a teaspoonful, which quantity contains about gr. i. of the iron compound, gr. $1\frac{3}{4}$ of the quinine, and gr. $\frac{1}{30}$ of strychnine. This syrup does not keep well, and is at best an unnecessary preparation.

(Sodio-) Ferric Pyrophosphate.

Under the title of *Ferri Pyrophosphas Solubilis*, Soluble Ferric Pyrophosphate, a scale preparation is official in the United States Pharmacopœia, which is a twin brother of the "phosphate" described above, the mode of preparation being identical, except that sodium pyrophosphate is substituted for the ordinary orthophosphate. The present scales are apple-green in color, freely soluble, of little taste, and perfectly bland. They constitute, therefore, a favorite form for giving iron. Chemically, here, as also with the other "phosphate," the exact relation between the two acid and basic radicals represented in the two salts conjoined in the preparation is not known. Dose, from 0.12 to 0.30 gm. (gr. ij. to v.) three times a day, in pill or solution.

Passing from the scale preparations, other ferric compounds are as follows:

Ferric Hypophosphite: $Fe_2(H_2PO_2)_6$.

The salt is official as *Ferri Hypophosphis*, Ferric Hypophosphite. It is a grayish-white powder, of little taste, permanent in air, only sparingly soluble in water, and insoluble in alcohol. It was introduced into medicine as a means of combining the virtues of a hypophosphite, as such, with those of iron. From the point of view of its qualities as a chalybeate, it is mild in operation, but feeble in effect. Dose, from 0.30 to 0.65 gm. (gr. v. to x.) three times a day, in powder or pill.

Ferric Valerianate: $Fe_2(C_5H_9O_2)_6$.

This salt is official as *Ferri Valerianas*, Ferric Valerianate. It occurs as a fine, tile-red powder, insoluble in cold water, decomposed by boiling water, freely soluble in alcohol. It has little taste, but smells faintly of valerianic acid. It is designed to yield the double virtues of a valerianate and a chalybeate, but so far as the latter purpose is concerned it is feeble. Dose, from 0.06 to 0.20 gm. (gr. i. to iij.).

The remainder of the iron salts, again, form a natural group. They are all ferric salts of the stronger so-called mineral acids, and are characterized by free solubility in water, and the possession of intensely strong astringent, or even, most of them, styptic, qualities. Their taste is harsh and puckery, with a combined, strong, inky, and acidulous flavor—on the whole, very decidedly disagreeable. With the exception of the ammonio-sulphate, they yield solutions of a color ranging from a golden-yellow to a deep orange or reddish-brown. They comprise the most powerful representatives, both of the chalybeate and hæmostatic virtues of iron, and in overdose are capable of producing irritant poisoning.

Ferric Chloride: $Fe_2Cl_6.12H_2O$.

Ferric chloride, commonly called also *sesquichloride* and *perchloride*, is the most powerful known combined chalybeate and styptic, and has the qualities mentioned above developed to the highest degree. It is official as follows:

Ferri Chloridum, Ferric Chloride. Iron wire is treated with dilute hydrochloric acid, whereby ferrous chloride forms, with effervescence of hydrogen. The solution of the ferrous salt is then treated with additional hydrochloric acid, followed by nitric acid, by which means the ferrous is converted into the ferric chloride. The resulting solution, which under the details of the process is hot and concentrated, becomes a crystalline mass on cooling. Ferric chloride, thus derived, is in lumps of crystalline texture, orange-yellow in color, without smell, but of a harsh, chalybeate, and sour taste. It deliquesces with great readiness, dissolves freely in water, and is also soluble in alcohol and ether. The salt is convenient for ordering in solution for styptic purposes; it is a powerful but harsh hæmostatic. Applied to a bleeding part it forms, with the coagulable elements of the part, a reddish, slimy, pultaceous slough—an operation entailing a good deal of irritation. Because of such irritation, the so-called subsulphate of iron, which irritates much less, while it is hardly inferior in styptic power, is commonly preferred. If the chloride be used, and the bleeding area is small, as in the case of hemorrhage from a tooth socket, a concentrated application may be made by taking a drop or two of a deliquesced sample, or by mixing a small fragment of the solid stuff into a paste with a very little water. For more extended applications, solutions may be ordered of strengths ranging from five to twenty per cent. or so. Strong solutions, even so strong as fifty per cent., have been used to inject varicose aneurisms, but in some instances with fatal consequences.

Liquor Ferri Chloridi, Solution of Ferric Chloride. This is an original solution wherein ferric chloride is formed exactly as described above. It contains 37.8 per cent. of anhydrous salt, with some free hydrochloric acid, and is a dark-reddish fluid. It may be used as a strong solution for styptic purposes, or in doses of a few drops, very largely diluted, as a chalybeate medicine, but its essential purpose is to afford the preparation next to be described.

Tinctura Ferri Chloridi, Tincture of Ferric Chloride, "Muriated Tincture of Iron." The above solution of the chloride is diluted with three times its own volume of alcohol, and the mixture is ordered to be kept before dispensing for at least three months. The object of the latter requirement is to afford time for a slow reaction that takes place between the free hydrochloric acid derived from the original iron solution and the alcohol, whereby an ethereal body is formed, which imparts the peculiar flavor to the tincture, and is commonly accredited—perhaps justly—with having something to do with the somewhat peculiar effects of this preparation. Tincture of ferric chloride is a clear, yellowish-brown fluid, of a rough, astringent, acid, and ferruginous taste. It is decomposed by alkalies, alkaline earths and their carbonates, astringent vegetable infusions, and mucilage of acacia. In its effects it is strong enough in ferric chloride to be locally styptic, and, if swallowed in considerable quantity, to set up irritant poisoning. Its almost sole application is as a chalybeate medicine, in which rôle it is unsurpassed. Besides being of avail in anæmia and chlorosis, it often shows marked power in the individual diseases—acute tonsillitis, diphtheria, scarlet fever, and erysipelas—if given boldly in full doses. Moderate doses, furthermore, will often seem to oppose, so far as medicines can, the progress of kidney degeneration. In prescribing this tincture it must be borne in mind that it is a powerful medicine; that even in moderate doses it

tends to blacken, if not to injure, the teeth, to irritate the stomach, and constipate the bowels, while in large doses it may cause, in addition, headache and urino-genital irritation. Yet in the acute diseases mentioned above, in which large doses are so commonly prescribed, the medicine is remarkably well borne. The dose of the tincture ranges from ♏ ij. to x. or so, three times a day, in anæmia, to a teaspoonful, or more even, every hour or two, in the grave diseases requiring full dosage. The medicine must be well diluted, at least fourfold, with water, and the addition of some glycerin—about twenty-five per cent. of the potion as swallowed—remarkably disguises the harsh, unpleasant taste of the draught without affecting its efficiency. The dose should be sucked through a glass tube and the mouth well rinsed after the swallowing, and the administration should be preferably a while after meals rather than before. In anæmia good results often follow the giving of small and copiously diluted doses of the tincture—two drops diffused through a tumblerful of water. And thus administered, the medicine is practically freed from the objectionable taste and irritant action on the stomach which often preclude its use in larger dosage.

Basic Ferric Sulphate: $Fe_4O(SO_4)_5$.

This salt closely resembles the chloride in intense styptic quality, yet differs from the same in the advantageous way of being decidedly less irritant. It is official in the United States Pharmacopœia only in an original solution, as follows:

Liquor Ferri Subsulphatis, Solution of Ferric Subsulphate, "Monsel's Solution." Ferrous sulphate in a fixed proportion is added to a mixture in fixed proportion of sulphuric and nitric acids, at the boiling temperature. Conversion of the ferrous to the ferric sulphate results, but, by virtue of the proportion of sulphuric acid taken, it is the basic salt that forms. After the reaction is complete the solution is brought, by the addition of distilled water, to the standard strength—a strength "corresponding to about 13.6 per cent. of metallic iron" (U. S. P.). This solution is a deep ruby-red fluid, analogous in all general characteristics to the solution of the chloride. It is especially intended and used as a styptic, in which capacity it is pre-eminent.

Solution of the subsulphate may be applied clear to parts within reach; may be swallowed in ten-drop doses, well diluted, in hæmatemesis, and inhaled in atomized spray, in a two-per-cent. aqueous dilution, in hæmoptysis. The solution is also, of course, a possible chalybeate medicine, but, having no especial advantage over the tincture of the chloride, is rarely used for its medical virtues. The dose would be ten drops or so, largely diluted. This solution is the one formerly known as "solution of persulphate of iron"; and is dispensed whenever such solution is prescribed.

Normal Ferric Sulphate: $Fe_2(SO_4)_3$.

The normal sulphate differs, medicinally, from the basic only in being more irritant in its local effects. It is official in the United States Pharmacopœia for pharmaceutical purposes only, and in the following original solution:

Liquor Ferri Tersulphatis, Solution of Ferric Sulphate. This solution is made in precisely the same manner as the foregoing, only with such proportion of the ingredients as to yield the normal instead of the basic sulphate. It is of a strength "corresponding to about eight per cent. of metallic iron" (U. S. P.). It is important as being the preparation out of which ferric hydroxide is made, both when this compound is called for as an antidote to arsenic, and also when it is required for the making of the scale preparations of iron, as already seen. This solution is efficient as a chalybeate and as a hæmostatic, but, having no advantages for such application, is rarely so used.

Ferric Nitrate: $Fe_2(NO_3)_6$.

This salt is substantially an unnecessary duplicate of its congeners just considered. Like the ferric sulphates, it is official in the United States Pharmacopœia only in an original solution, as follows:

Liquor Ferri Nitratis, Solution of Ferric Nitrate. Fresh and moist ferric hydroxide is treated with nitric acid, and the resulting solution of ferric nitrate is brought to standard strength ("about 6.2 per cent. of the anhydrous salt") by the addition of distilled water. The solution is a clear, amber or reddish-colored liquid, sour and styptic in taste. It has been given as a chalybeate, in doses of from ten to twenty-five drops.

Ammonio-ferric Sulphate: $Fe_2(NH_4)_2(SO_4)_4.24H_2O$.

The salt is official under the title *Ferri et Ammonii Sulphas,* Ferric Ammonium Sulphate, "Iron Alum." It has the chemical structure and, physiologically, the peculiar strong astringency, without excessive irritation, of the true alums. It occurs in octahedral crystals of a delicate lilac or violet color, which dissolve freely in water, but are insoluble in alcohol. It is used in strong solution, as a styptic, or internally, as a combined astringent and chalybeate, in cases of anæmia with passive discharges. Dose, from 0.30 to 0.65 gm. (gr. v. to x.) three times a day.

Besides the foregoing official preparations there are numerous others, not official either because now dismissed from the Pharmacopœia as obsolete, or because not deemed worthy of recognition, or because newly proposed. Of the first class, two ferrous salts were dismissed in the last (1890) revision of the United States Pharmacopœia, namely, *ferrous bromide* and *oxalate.* The *bromide* used to be official in a syrup which was substantially a duplicate in all ways of the syrup of the iodide, and the oxalate was official as the salt itself. *Ferrous oxalate* is a lemon-yellow crystalline powder, practically insoluble in water. It was proposed for chalybeate use on the strength of an assertion that it does not constipate, but it never found favor. It may be given in doses of a few grains.

Dialyzed iron at one time had considerable vogue in medicine, although never recognized by the United States Pharmacopœia. As a chalybeate it is bland, but feeble, and as an antidote to arsenic—its other possible application—it is considered inferior to the "hydrated oxide with magnesia," on the score that the insoluble compound that it forms with the arsenical is less stable in the presence of acids.

Dialyzed iron is substantially a solution in water of ferric oxychloride, whose composition varies from Fe_2Cl_6, $12Fe_2O_3$ to Fe_2Cl_6, $95Fe_2O_3$. It is properly made by precipitating an aqueous solution of ferric chloride with water of ammonia, shaking until the precipitate redissolves (formation of oxychloride), and then dialyzing over water, continuing the dialysis, with frequent changing of the water, so long as any traces of hydrochloric acid appear. The product is then assayed, and, by addition of water, is brought to the standard strength of ten per cent. of dry oxychloride. Much of the dialyzed iron in market, however, is made not in this way, but simply by adding fresh ferric hydroxide to a solution of ferric chloride so long as it continues to dissolve, and then filtering. Such preparation is, of course, properly not *dialyzed* iron at all.

Genuine dialyzed iron is a clear, reddish-brown solution, odorless, practically tasteless, and perfectly bland and innocent. Any decidedly ferruginous or styptic taste probably means a sham specimen. The true article mixes in all proportions with distilled water, alcohol, glycerin, and simple syrup; but upon admixture with alkalies, many salts—notably sodium chloride—and most organic matters, it suddenly transforms itself into a soft gelatinous mass, in color and consistence much resembling clotted blood. Such reaction must inevitably ensue on swallowing, and in the colloidal state resulting the iron is incapable of absorption. What of dialyzed iron ever gets access to the blood must, therefore, be through some chemical attack upon it by the alimentary juices, with the development of new and soluble iron

compounds. The dose of dialyzed iron must be large if any effect at all is to be expected—at least a teaspoonful of the usual ten-per-cent. solution three times a day. As an antidote to arsenic, teaspoonful doses should be given every five minutes; and since now gelatinizing is of advantage, some common salt should follow each dose.

Dialyzed iron has been injected hypodermatically, but in some instances with the following of abscess at the site of puncture.

A distinct class of preparations is afforded by certain compounds of iron with *proteid* substances, designed to furnish iron in a condition allied to the "organic" iron of hæmoglobin, and this because of the notion that ordinary iron preparations are not capable of assimilation (see *ante*). Of these preparations the most important are those containing iron as an *albuminate* or a *peptonate.*

By reaction of solution of ferric chloride upon albumin *ferric albuminate* forms, which precipitates from the solution by addition of a solution of common salt. The precipitated albuminate, washed and dried, appears as a brown powder, soluble in water, especially under slight acidulation with hydrochloric acid. The preparation is bland, and may be prescribed as a chalybeate in doses of from 1.3 to 1.95 gm. (gr. xx. to xxx.), to be taken in pill or dissolved (freshly) in water. In this preparation the iron is not in the condition of "organic" iron, for a solution of the albuminate precipitates with alkaline sulphides the same as does a solution of an ordinary salt of iron.

Ferric peptonate can be obtained in the form of dried scales, resembling in character the scale preparations of ferric citrate (see *ante*). A solution of freshly peptonized albumin is treated with dialyzed iron under certain special pharmaceutical manipulations, and from the solution of ferric peptonate finally obtained scales are prepared in the usual way. These scales are brown in color, contain about one-quarter of their weight of iron, and dissolve slowly in cold water. They make a bland chalybeate, in which, however, as in the case of ferric albuminate, the iron is in "inorganic" and not "organic" condition.

Under the name of *ferratin* there has been offered a preparation of iron made to imitate the normal ferratin discovered by Schmiedeburg in the liver of the hog. Artificial ferratin is made by reaction of albumin with a double tartrate of iron and one of the alkali metals. The preparation is in the form of a brownish powder, almost insoluble in water but soluble in alkaline liquids. It contains from six to eight per cent. of iron. It is bland and may be given, as a chalybeate, in doses of a few grains several times daily. It is claimed that in ferratin the condition of the iron is certainly very near to that of natural "organic" iron, but yet the preparation reacts with the hæmatoxylon test, which true "organic" iron does not do.

Carniferrin is a preparation closely allied to ferratin in its properties and reactions. It is a compound of iron with phosphocarnic acid. It is in the form of powder, tasteless and bland; is soluble in alkaline fluids, and may be given as a chalybeate in doses of a few grains. It contains about thirty per cent. of iron.

Ferralbumose is another preparation in form of powder, obtained by precipitating with a solution of ferric chloride a solution of albumose derived from meat by treatment with artificial gastric juice.

The various proteid preparations of iron have the certain merit that they do not upset the stomach and that they are readily absorbed. They are, however, comparatively expensive, and it is not demonstrated that they cure chlorosis any more effectively than well-selected preparations from among the pharmacopœial list.

III. General Therapeutics of Iron Compounds.—Excepting certain special applications of individual compounds, the therapeutics of iron comprises the internal use for the cure of anæmic conditions, and the local employment for astringent or styptic purpose. Concerning the two applications, the following practical points are to be made:

Anæmia.—1. Except in pernicious anæmia, iron proves so serviceable that, given an anæmic state, the medicine is commonly held to be indicated, unless there be either fever or a tendency to active hemorrhage—conditions apt to be aggravated by iron. 2. In the matter of choice of preparations, in general, the astringent chalybeates are more powerful than the bland, but yet it will be wiser to try the latter kind first if either the stomach be over-irritable, the bowels strongly prone to constipation, the teeth fragile, or the patient of careless habits; or if, as with children, the disagreeable taste of the astringent preparations be particularly obnoxious. On the other hand, the astringent chalybeates are especially advantageous when the appetite is poor and yet the stomach is not unduly sensitive, or when there is general laxity of tissue, or a tendency to passive fluxes or hemorrhages. 3. In particular, concerning the preparations, if an astringent be wanted, the tincture of the chloride answers every purpose as a fluid form, and the dried sulphate (ferrous) as one for giving in solid form in pill. If a bland compound be required, there may be prescribed, in powder, reduced iron and the saccharated carbonate; in pill, reduced iron, pills of the carbonate, "Blaud's pills," and the citrate; and in solution, the potassio-tartrate or the pyrophosphate, with the others of the scaled preparations as substitutes. For the rest, the various compound salts and the fancy pharmaceutical preparations are often convenient, but are never indispensable. 4. The frequency of dosage is most conveniently fixed at three times a day, and the doses, as already given, are intended for such frequency. But in exceptional uses of iron, as of the tincture of the chloride in diphtheria, the frequency will be far different—according to the severity of the case, even to hourly administration, day and night. 5. The timing of the doses is best arranged to be at meal-hours, the administration to be rather after than before eating. This certainly with the astringent chalybeates, but with the very bland the rule need not be enforced.

To Arrest Hemorrhage.—1. In general, it must be remembered that arterial hemorrhage belongs by right to the domain of surgery, and that medicinal hæmostatics are only proper when the vessel is either too small for mechanical measures or is inaccessible. This rule needs especial observance in connection with the iron styptics, for if they fail to stop the bleeding the surgical search for the bleeding point, through the indiscriminately slough-obscured tissue resulting from the styptic application, is made exasperatingly difficult. Furthermore, this same slough caused by the styptic seriously interferes with speedy healing of the wound. 2. Of the styptic preparations the official solution of the subsulphate is generally the best, because the least irritant; but if extreme power be required, and the area to be subjected to the application is small, a drop or two of the deliquesced chloride may be allowed.

The individualized applications of iron compounds are of the hydroxide, as an antidote to arsenic; of ferrous sulphate, as a disinfectant; of the tincture of the chloride as a medicine of peculiar virtues; of the solution of ferric sulphate for purposes of pharmacy, and of the ammonio-sulphate as a pure astringent.

Edward Curtis.

[1] Willcocks: The Practitioner, vol. xxxi., pp. 7 and 94.

IRONDALE SPRINGS.—Preston County, West Virginia.

Post-Office.—Independence.

Access.—Viâ Baltimore and Ohio Railroad to Hardman's Siding, one and one-half miles west of Independence, thence by the Iron Valley Railroad three and one-half miles to the springs.

The Irondale Springs occupy a very attractive location about 1,200 feet above the sea-level, but the place is not at present used as a resort. The water is bottled and used commercially, being recommended by physicians in many of the large Eastern cities. It has been analyzed

by Prof. A. A. Breneman, formerly of Cornell University, with the following results:

ONE UNITED STATES GALLON CONTAINS:

Solids.	Grains.
Calcium sulphate	60.42
Magnesium sulphate	4.34
Potassium sulphate	6.76
Aluminum sulphate	11.34
Manganese sulphate	2.86
Iron sulphate with cobalt and nitric acid	Trace.
Sodium chloride	1.36
Silica	1.44
Iodine with sodium	Trace.
Vegetable and volatile substances	8.24
Total	96.76

This water, as shown by the analysis, is exceptionally rich in manganese, besides containing a large amount of alum. The following facts relating to its therapeutic effects are gathered from an article contributed to the New York *Medical Times* by Dr. Samuel Swift. This water, he says, possesses undoubted tonic and diuretic properties. It also acts as a sedative to the gastric mucous membrane, and in virtue of this fact it is highly extolled in cases of gastric irritability. It acts well in the nausea and vomiting of pregnancy, and has been found useful in chronic diarrhœa. In Bright's disease and in anæmia and chlorosis it has seemed to possess decided remedial value. The water is not unpleasant to the taste, and has no disagreeable after-effects. The Irondale Spring salts, made by evaporating the water, are also on the market. *James K. Crook.*

IRON LITHIA SPRINGS.—Tazewell County, Virginia.

POST-OFFICE.—Tazewell. Hotel.

ACCESS.—Viâ Clinch Valley Division of the Norfolk and Western Railroad to Tip-Top Station, thence by private conveyance two miles to the springs.

These springs are charmingly located in the Alleghany Mountains at an elevation of 2,700 feet above the sea-level. They were but recently discovered, but have already become well known. A hotel has been erected capable of accommodating fifty guests. The many advantages of climate, mineral springs, scenery, etc., which are found here will doubtless bring the place into prominence in the near future. The springs are five in number and discharge about 1,000 gallons of water per day. An analysis by Dr. Henry Froehling, of Richmond, in 1890, shows the following ingredients:

ONE UNITED STATES GALLON CONTAINS:

Solids.	Grains.
Magnesium sulphate	4.71
Calcium sulphate	1.71
Barium sulphate	.09
Strontium sulphate	Trace.
Iron sulphate	5.08
Manganese sulphate	.36
Aluminum sulphate	8.05
Potassium sulphate	.51
Sodium sulphate	.25
Lithium chloride	.18
Sodium	.39
Sodium iodide	Trace.
Aluminum phosphate	.11
Sulphuric acid (free)	.51
Silicic acid	1.60
Total	23.55

Carbonic acid gas, 5.20 cubic inches.

This water is distinguished by the not inconsiderable quantity of manganese which it contains. This remedy has been found valuable in certain female complaints, especially in functional amenorrhœa. In addition it contains a very large proportion of iron and alum, and a considerable amount of sulphate of magnesia. Taken altogether, it may be pronounced a very valuable mineral water, and will be found useful in a large class of cases requiring a local astringent, a general ferruginous tonic, or a uterine detergent. *James K. Crook.*

IRON, ORGANIC COMPOUNDS OF.—The following preparations are used to replace the inorganic salts of iron, as many believe that these organic combinations are better borne by the stomach and more certainly absorbed.

Carniferrin is the iron compound of phospho-carnic acid prepared from meat. It contains thirty per cent. of iron and is compatible with acids or alkalies. Dose 0.2–0.5 gm. (gr. iij.–viij).

Carniferrol is a liquid preparation of iron and meat peptone.

Ferratin is an artificial ferrated albuminic acid designed to represent the natural iron compound of the hog's liver. It contains about seven per cent. of iron and its dose is 0.3 to 1 gm. (gr. v.–xv.).

Ferratin-sodium is a soluble form of ferratin which may be added to milk or other liquid foods.

Ferratogen is an insoluble yellowish powder made as follows: yeast is grown on a medium containing iron, the nuclein thus formed being isolated and digested with gastric juice, then washed with alcohol containing hydrochloric acid. It represents one per cent. of iron and is said not to be affected by the gastric juice, and to be well absorbed in the intestine.

Ferrinol is an iron nucleid containing about six per cent. of iron.

Ferropyrin is an orange-colored powder made by acting on antipyrin with ferric chloride. It contains 64 per cent. of antipyrin and 12 per cent. of iron, is soluble in water and alcohol, and is said to have remarkable styptic properties without caustic effects. It is used in 20 per cent. to full strength as styptic in uterine and other hemorrhages, in 1- to 3-per-cent. solution as an astringent in gonorrhœa, and in dose of 0.3 to 1 gm. (gr. v.–xv.) internally for anæmia and chlorosis.

Ferrosol is a saccharated ferrous oxide with sodium chloride.

Fersan is an acid albumin obtained from blood corpuscles, and is a ferruginous nutritive containing a high percentage of phosphorus. It is said to rank high as a hæmatinic and as an albuminoid food. Dose 1 to 2 gm. (gr. xv.–xxx.) three times a day.

Hæmalbumin (*Dahmen*) contains hæmatin, hæmoglobulin, paraglobulin, serum albumin, and the inorganic constituents of blood.

Hæmaticum is a red-brown, clear hydroalcoholic liquid containing indifferent compounds of iron.

Hæmatogen (*Bunge*) is a nucleo-albuminoid preparation.

Hæmatogen (*Hommel*) is defibrinated blood from which the serum has been removed and a minute quantity of creosote added.

Hæmatogen (*Marfori*) is a soluble ferrated albuminic acid similar to ferratin and containing 0.7 per cent. of iron.

Hæmatol is a sterilized hæmoglobin containing glycerin and brandy.

Hæmogallol is an indifferent preparation of iron obtained by the reducing action of pyrogallol on the hæmoglobin of ox-blood. It is a red-brown powder the iron of which is not changed to chloride by the gastric juice. Dose 0.3 to 1 gm. (gr. v.–xv.).

Hæmol, a congener of hæmogallol, is obtained by the reduction of hæmoglobin with zinc dust. This substance has been combined with various metals forming:

Arseno-hæmol containing one per cent. of arsenous acid.

Bromo-hæmol containing 2.7 per cent. of bromine.

Copper-hæmol containing two per cent. of copper.

Hydrargyro-iodo-hæmol containing 12.35 per cent. of mercury and 28 per cent. of iodine.

Iodo-hæmol containing 16.6 per cent. of iodine.

Zinc-hæmol containing one per cent. of zinc.

Triferrin is a compound introduced by Salkowski, containing iron, phosphorus, and paranucleinic acid obtained from the casein of cow's milk. It contains about 2.5 per cent. of phosphorus and 22 per cent. of iron, is insoluble in acids (gastric juice) and soluble in solution of sodium bicarbonate. With doses of 0.3 gm. (gr. v.) three times a day, Klemperer had good results in twenty-one cases of anæmia.

Other organic iron preparations are the albuminate,

peptonized albuminate, ammonium arseno-citrate, caseinate (nucleo-albuminate), dextrinate, glycero-phosphate, inulate, peptonate, and vitellinate (iron and egg yolk) of iron, iron and sodium albuminate and citro-albuminate, hæmatin-albumin, hæmochromogen, hæmoferrum, hæmoglobin, methæmoglobin, pepto-ferro-mangan, and ferro-somatose (two per cent. iron). *W. A. Bastedo.*

IRON, POISONING BY.—Metallic iron and those compounds of iron which are insoluble in water are not poisons. The soluble salts, however, though not active poisons, have an irritant action, and are capable of destroying life when taken in large doses and in a concentrated state. The continued administration of even medicinal doses produces, after a time, decided gastric disturbance. It is probable that all the soluble preparations may act as irritant poisons when administered in large doses. The most important, however, from a medico-legal point of view, are ferrous sulphate (copperas, green vitriol), ferric chloride (perchloride), which is used medicinally in the form of tincture, and the tannate in the form of ink.

The salts of iron are rarely administered for criminal purposes. Most of the reported cases of poisoning have been the result of accident, or of the use of the sulphate or the tincture of the chloride of iron in attempts at abortion. The symptoms which follow the administration of large doses of the preparations named are essentially similar to those produced by the irritants in general. There are a styptic taste in the mouth, nausea, vomiting, pain in the stomach and intestines, and purging. The evacuations are black, owing to the conversion of the iron salt into a tannate by the tannic acid of the food, or into a sulphide by the sulphureted hydrogen resulting from decomposition in the intestines. Irritation of the genito-urinary passages is sometimes observed. The tincture of the chloride of iron is more corrosive in its action than the sulphate, by reason, apparently, of the free hydrochloric acid which it frequently contains. Its injection into the cavities of the body, for the purpose of arresting hemorrhage, has proved fatal.

The amount of any of the preparations of iron required to endanger life is not accurately known, but appears to be quite large. In most of the cases in which the sulphate has been taken the amount was unknown. Recovery has taken place after a dose of 31 gm. (℥ i.) of the sulphate (Christison). A case is reported in which 48 gm. (℥ iss.) of the tincture of the chloride of iron proved fatal in about five weeks (Christison). Recovery has taken place after doses of 32 to 96 gm. of this preparation. The favorable issue is probably due, in many cases, to the early occurrence of vomiting.

The results of experiments on animals are not uniform. Gmelin states that 7.7 gm. (ʒ ij.) of the sulphate of iron administered to dogs by the mouth caused vomiting only; that 2.6 gm. (gr. xl.) administered to rabbits produced no injury; and that 1.3 gm. (gr. xx.) injected into the veins of a dog produced no symptom whatever. Dr. Smith, however, states that 7.7 gm. will prove fatal to dogs when administered by the mouth or applied to a wound.

The post-mortem appearances are those of a simple irritant, and are confined, so far as has been observed, to the stomach and upper part of the intestines. In acute cases the contents of the intestines will probably present a black appearance, owing to the presence of the tannate or the sulphide of iron.

Iron is eliminated to some extent in the urine. A small amount only is absorbed in any event, the greater part escaping in an insoluble form with the fæces.

Treatment consists in the use of the stomach pump, or of emetics, if necessary. Magnesia or dilute solutions of alkaline carbonates should be administered as antidotes, and these should be followed by demulcents.

William B. Hills.

IRRADIATION is the diffusion or, as one might say, "the overflowing" of the nerve impulse over the boundaries of the pathway within which it usually travels.

If a local cardiac condition gives rise to pain not only in the region of the heart but also in the arm, the latter pain is an irradiated one, belonging as it does to quite another territory than that supplied by the nerves of the heart. This irradiation of visceral pains into cutaneous areas follows definite laws which have been laid down by Head in his classical researches on this subject.

But a pain may irradiate not only from a visceral or sympathetic to a cutaneous or other cerebro-spinal nerve territory; it may also irradiate from one nerve to the other or from one branch of a nerve to the other *within* the cerebro-spinal system. For instance, pain arising from a partial lesion of the second branch of the fifth nerve (toothache) may spread not only over the entire second branch, but even over the third branch of that nerve. A pain may also irradiate from one side to a (usually symmetrical) point on the other side of the body.

While it has thus been customary to apply the term irradiation to conscious sensory impressions, which need not necessarily be painful, there is no reason why it should not be applied to motor and reflex innervation as well, the physiological process and its anatomical basis being probably the same. For instance, if tapping of the patellar tendon which normally causes a contraction only of the quadriceps muscle of the same side, produces also muscular contractions in the other lower extremity, as is the case in many organic cerebral and particularly spinal lesions, we certainly have the right to speak of it as irradiation.

Similarly the associated movements often accompanying motor acts, for instance, movements of the jaw accompanying the act of cutting with scissors or of cracking nuts, should also be classed under the heading of irradiation.

The small space allotted to this article does not allow us to enter on the mechanism of irradiation further than to say that it must take place at the points of passage from one neuron to another, the multiplicity of connections of each neuron giving a wide range of possibilities in this direction, especially if it is considered that in every case a chain of at least two neurons must be passed before the stimulus reaches its final destiny.

B. Onuf (Onufrowicz).

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Henry Head: Die Sensibilitaetsstoerungen der Haut bei Visceralerkrankungen. Translated by Dr. Wm. Seiffer, Berlin, 1898, Verlag von August Hirschwald. Also articles in Brain, vol. xvi., part i., 1893; vol. xvii., part iii., 1894; vol. xix., part ii., 1896, and vol. xxiv., 1901.

IRRITABILITY.—Irritability may be defined as the quality possessed by living tissues, animal as well as vegetable, of reacting toward stimuli* with manifest dynamic changes. These changes† may become apparent directly or indirectly, in the form of muscular contraction, glandular function, sensory perception, amœboid movements, flagellate movements, or streaming of protoplasm, or in other ways.

The dynamic changes produced by the stimulation may manifest themselves in the stimulated tissue itself or be inferred indirectly by the effects upon other tissue. For example, the dynamic alterations wrought by stimulation of a motor nerve may find an indirect expression in the form of a muscular contraction; but their presence in the nerve may be demonstrated also directly by the so-called "current of action" or "negative variation," produced in the nerve by the stimulation, and demonstrable with a galvanometer.

This latter direct method is the more accurate one, giving a truer measure of the irritability of the stimulated

* A definition of *stimulus* is given in a later section of this article.

† The nature of these changes in the case of the nerve protoplasm has been made a subject of special study by A. F. Mathews, the result of whose researches was published in the New York Sun. He concludes that "nerve protoplasm" is stimulated (*i.e.*, excited) by the passage of colloidal particles from a condition of solution to that of gelatination. The irritability of a nerve is diminished whenever the solution of the colloids is rendered more permanent. It increases as the nerve approaches the state of gelatination.

tissue. A study of the action of curare convincingly demonstrates the truth of this statement. Curare acts on the motor nerve endings in such manner as to abolish the faculty of transmission of the nerve impulse from nerve to striated muscle. Stimulation of the nerve remains, therefore, without effect on the muscle, but the muscle continues to respond promptly to direct stimulation. That the nerve too retains its irritability is shown by the fact that its stimulation, be such of a mechanical or chemical or electric or other nature, gives rise to a "current of action" demonstrable by a galvanometer.

In a case of slight curare poisoning the faculty of transmission of the impulse from nerve to muscle is not entirely abolished, but only impeded more or less according to the severity of the poisoning, so that strong stimulation of the nerve will produce only a slight muscular contraction. Nevertheless the irritability of the nerve remains unimpaired, as shown by the "current of action." Consequently if in this case we were to measure the degree of irritability of the nerve by the effect of its stimulation on muscle, we should clearly come to a wrong conclusion.

However, the method of direct measurement of the irritability of a tissue is often practically not feasible, and we then have to resort to the *indirect* method in spite of its fallacies.

The degree of irritability of a tissue is expressed by the inverse proportion between the strength of the stimulus and the demonstrable or manifest dynamic change produced. It may be expressed by the formula: $I=\frac{D}{St}$ in which I denotes irritability while the denominator St represents the stimulus, and the numerator D the demonstrable dynamic change produced by it.

In many cases the disproportion between the strength of the stimulus and the amount of demonstrable dynamic changes wrought by it is very great, the amount of energy evolved by the stimulation being often ten times or even hundreds of times greater than the amount of energy represented in or spent by the stimulus itself.

Verworn gives the following interesting instance in substantiation of this statement: "A nerve-muscle preparation is suspended on a myograph, the muscle is loaded with a weight of 100 gm. and its nerve is laid over a glass plate supported by a stand (Fig. 2965). Upon the nerve rests a small aluminum pan having a sharp keel on the lower side, and into this a weight of 10 gm. falls from a height of about 10 cm. At the moment of stimulation the muscle contracts and raises the 100 gm. about 1 cm. Here the quantity of energy that corresponds to the work of the muscle is approximately ten times greater than the quantity of energy that has operated as a stimulus upon the muscle."

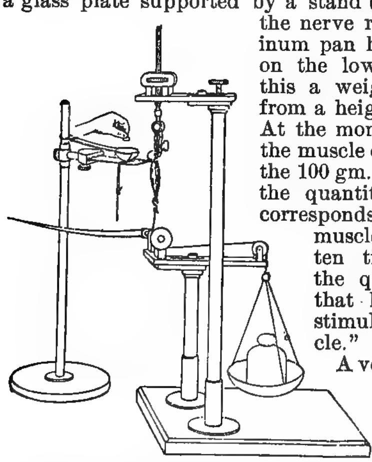
FIG. 2965.—Mechanical Contrivance for Demonstrating the Disproportion between Stimulus and Effect of Stimulus. (From Verworn.) For details see the text.

A very striking parallel fact from the inorganic world is familiar: The spark from a small battery which, applied to the human body gives a hardly noticeable sensation, is sufficient to blow up a whole house if applied to a definite quantity of nitroglycerin in the proper manner.

In accordance with the law of the preservation of energy this disproportion must be explained, not by the addition of energy not before existent, but by the transformation of one form of energy into another form—for instance, of chemical energy into physical energy.

However, while in the instance of the spark exploding the nitroglycerin, the produced effect is to a great degree independent of the size of the "stimulus," inasmuch as a small spark applied to a certain quantity of nitroglycerin will produce no less explosive effect than a large flame applied to the same quantity, this does not hold true or at least is not the rule for the phenomena of irritability in animal and vegetable life. Here—and this is especially true for the nervous and muscular systems—very frequently the manifest dynamic change produced by a stimulus increases with the size of the latter, but only up to a certain point; beyond that point it rapidly diminishes and the stimulus then rapidly reaches that size which causes death of the tissue.

Here a definition of the term *stimulus* is in order. In harmony with the definition of irritability, a stimulus may be defined as any agency which is capable of producing manifest or demonstrable changes of dynamics in the tissue on which it acts; changes that may be directly demonstrable in the stimulated tissue itself or indirectly by the effects on some other tissue, as has already been explained in the case of nerve and muscle.

This definition comes very near that of Verworn, who distinguishes the vital phenomena as spontaneous phenomena—when all the external conditions remain unchanged, and phenomena of stimulation—when other influences act upon them, and who accordingly defines a stimulus as every change of the external agencies that act upon an organism. This definition has been slightly modified by us in view of the fact that, as Verworn himself remarks, a strict dividing line between spontaneous phenomena and phenomena of stimulation cannot be drawn. Wherein our definition corresponds with that of Verworn, however, is that both depressive as well as exciting agencies are included in the definition of stimuli, and this is perfectly appropriate if one considers that in many cases it is very difficult, if not next to impossible, to state whether the effect of the stimulation is depressive or exciting. In this connection the existence of inhibitory nerve fibres and nerves should be called to mind, the excitation of which produces a depressive instead of exciting effect on the tissue (muscular, glandular, etc.) which it innervates, and yet the agency which thus acts on said nerve or nerve fibres must be called a stimulus.

As to the kinds of agencies that may act as stimuli, such are very numerous and may be, according to Verworn, classified into chemical, mechanical (including sound vibrations), thermic, photic, and electrical.

Another distinction to be made is between the *exciting* and the *depressing* effects of a stimulus, by which is meant the increase or diminution respectively of the activity or function of the stimulated tissue. Almost every kind of stimulus probably may have either effect, according to the intensity, duration, and other attributes of the stimulus.

The responsiveness to all kinds of stimuli can be traced down to the lowest forms of life in the animal scale and is seen also in plants. As an instance of the irritability of certain plants to mechanical stimuli, one may mention that of Mimosa pudica, the leaves of which fold together when the plant is shaken; or, again, electrical currents have been seen to increase granular streamings in protoplasm of plants, such as Nitella and Tradescantia (quoted from Verworn).

No less interesting is the narcosis of plants as observed by Claude Bernard, who found that under the influence of chloroform certain Algæ (spirogyra) cease to evolve oxygen, certain Diatomeæ cease to secrete, and growth and division of plant seeds become arrested; while Mimosa pudica, when under the influence of ether, entirely loses its above mentioned responsiveness to mechanical stimulation.

The effect of mechanical stimulation on bacteria was shown by Horvath (confirmed by Meltzer), who observed not only inhibition of growth but even death and granu-

lar disintegration of these micro-organisms as the result of regular vibrations.

That bacteria too may be excited by light is shown in the Bacterium photometricum, the flagellum of which moves under exposure to light, but ceases to move when the amount or intensity of light diminishes beyond a certain level.

In amœbæ and amœba-like rhizopods responsiveness to all kinds of stimuli—chemical, mechanical, thermic, photic, and electric—has been seen by Engelmann, Max Schultze, Kühne, Verworn, and others. (See Fig. 2966.)

The ciliary and flagellar motion of infusoria too has been found to be influenced by all the above kinds of stimuli in the direction of acceleration as well as that of retardation. Narcotics, such as ether and chloroform, retard this movement (Engelmann); high temperatures up to a certain point accelerate and low temperatures retard it.

An adaptability of amœba-like organisms to stimuli of all classes, brought about by gradually increasing the amount of stimulation, has been demonstrated by Engelmann. This author noticed particularly that Actinospherium, a rhizopod, if placed in salt solutions of gradually increasing strength, could finally be made to extend its pseudopodia in solutions of such concentration as would have made it contract immediately to a ball and eventually would have produced death, had it been brought into them directly.

A parallel phenomenon in higher animals is observed in the adaptability of the organism to such poisons as morphine and the like.

However, this adaptability is by no means the rule, since in the case of the rectal and vesical sphincters, for instance, as Verworn points out, the response continues the same in spite of the prolonged stimulation to which they are subject.

In the course of evolution of the animal series the use of organs or tissues for particular purposes leads to such a differentiation that each organ or tissue becomes excitable particularly by a definite kind of stimulus. An instance of this is the retina, the exquisite responsiveness of which to photic stimuli makes it adapted for the purpose of vision. This is, however, not due solely to the photic responsiveness of the retina, but is greatly furthered by the refractive apparatus of the eye and the arrangement of the retinal elements, which make it possible to concentrate, differentiate, and isolate the stimulations in the most perfect manner for the particular purpose of vision.

Moreover, experiences with the Roentgen rays have convinced us that even in the highly differentiated organism of man the retina is not the only tissue that can be stimulated by light. The deep trophic cutaneous disturbances following long exposures to this kind of light bear out this statement; and similarly, sound vibrations, although finding a particularly responsive recipient in the peculiarly constructed auditory apparatus of the labyrinth, evidently also have some effect on other tissues.

The irritability par excellence of nerve tissue is shown among other things by comparison with that of amœbæ, since nerve fibres are put into activity by extremely feeble galvanic currents, while amœbæ demand much stronger currents for this effect.

Threshold and Threshold Value of Stimulation.—Very feeble stimuli cause no visible or demonstrable effects on the stimulated or other tissues. By gradually increasing the intensity of the stimulus a point is finally reached when its effect becomes just perceptible or demonstrable. This point is called the threshold of stimulation and the intensity of the stimulus producing this minimal effect is called the threshold value of stimulation. This threshold value is not an immutable entity but dependent on the demonstrable effect that is expected, as well as on other factors.

For instance, the threshold value for a stimulation of the planta pedis might be that degree of stroking which is sufficient to produce a plantar reflex; or it might be that degree of stroking which just suffices to give a conscious tactile impression. The first would be the threshold value of reflex, the other the threshold value of conscious perception for the tactile stimulus.

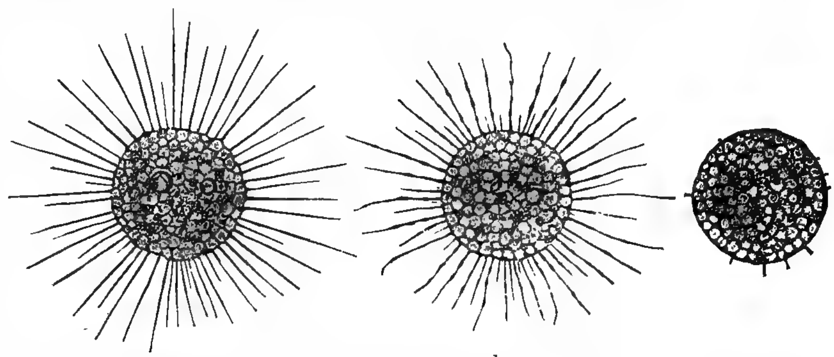

FIG. 2966.—Actinospherium Under Chemical Stimulation. (From Verworn.) *a*, Unstimulated; *b*, slightly stimulated; *c*, strongly stimulated.

For a motor nerve the threshold value of stimulation is usually measured by the intensity of the stimulus required to produce a minimal contraction of the muscle supplied by it; but we have seen in the instance of curare poisoning, which, by a paralysis of the endings of a motor nerve, prevents or impedes the transmission of the impulse from nerve to striated muscle, that the degree of muscular contraction does not give us any true measure of the irritability of the nerve and consequently not of the threshold value of stimulation of the nerve.

Another factor influencing the threshold value is the amount of "charging" existing in a given nerve or nerve-cell group previous to the stimulation. If, for instance, a cell group from which a motor nerve takes its origin is acted upon from some source or other by a temporary nerve impulse or by a continuous stream of nerve impulses (tonus) just weak enough not to produce a muscular contraction, then a very small amount of additional stimulation, whether such is a voluntary nerve impulse, a sensory stimulation acting by way of reflex, or an external direct stimulus, would suffice to transform the latent into potent energy and thus to cross the threshold of stimulation.

On the other hand the nerve impulses acting on a given cell group at the moment of an intended stimulation may be antagonistic to the latter and thus increase its threshold value in a corresponding degree.

B. Onuf (Onufrowicz).

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Max Verworn: General Physiology. An outline of the science of life. Translated from the second German edition by Frederick S. Lee, London, Macmillan Co., 1899.

ISCHL is one of the most frequented spas of Austria, being often visited by the Emperor and many of the nobility. It is situated in the centre of the "Salzkammergut," in a beautiful Alpine valley, at the point where the little river Traun empties into the Ischl. Its elevation is about fifteen hundred feet above the level of the sea. It possesses a mild, moist climate, the average temperature from May to the end of September being 61° F. Showers are very frequent during the early part of the summer, but the sandy soil absorbs the water quickly, so that

the walking is seldom rendered unpleasant. In the neighborhood of the salt works the atmosphere is very similar to that of the seashore.

The salt hills of Ischl and Hallstädt contain natural salt veins, consisting of saliferous clay mixed with gypsum, resting upon limestone seamed with marl and clay. Pure water is conveyed hither in pipes, becomes saturated with the salts, and the brine then flows into the salt houses in Ischl and Ebensee. The following is the composition of the brines coming from the Ischler and Hallstädter hills, calculated in parts per 1,000:

	Hallstädter brine.	Ischler brine.
Sodium chloride	255.26	236.13
Magnesium chloride	4.94	.93
Magnesium bromide	.16	.06
Potassium sulphate	4.62	.69
Sodium sulphate	3.25	3.84
Calcium sulphate	3.40	3.84
Total solids	271.63	245.49

The baths are prepared by mixing these two brines in the proportion of one-third Ischl and two-thirds Hallstädt, to which is often added a decoction of pine needles. There are also facilities for mud baths and for inhalations of salt spray.

There are also several mineral springs at Ischl. The following is their composition, computed in parts per 1,000:

	Schwefel-quelle.	Klebelsberg-quelle.	Maria-Louisenquelle.
Calcium carbonate	0.092	0.015	0.197
Magnesium carbonate	....	.011	.010
Calcium sulphate	.459	.244	.078
Potassium sulphate	.024	.018	
Sodium sulphate	4.125	.274	.071
Magnesium chloride	.732	.406	.098
Sodium chloride	17.005	5.118	5.580
Total solids	22.437	6.086	6.034

In the sulphur spring (Schwefelquelle) there is a considerable amount of free sulphureted hydrogen gas.

In addition to its being a fashionable watering-place, Ischl enjoys a well-deserved reputation as a health resort. The climate and the waters combine to render it admirably adapted for the treatment of nervous and irritable individuals, and of those debilitated by disease, dissipation, or too rapid growth. Children suffering from scrofulous troubles are often much benefited by a visit to the place. Inhalations of the brine spray are used in the treatment of chronic catarrhal affections of the air passages, and many female disorders are relieved by brine baths.

The accommodations at Ischl, at least up to within a few years, have been rather inadequate for the large number of visitors; the cost of living is in consequence somewhat high. There are many private villas in the place, and the scenery in the valley is charming.*

The beautiful situation and the mild, equable, soothing climate, and innumerable charming excursions round about, all conspire to render Ischl a delightful spot for a longer or shorter visit in the season, which lasts from July to the end of September.

It is an excellent resort for an "after-cure." Besides the diseases above mentioned, there may be added neuralgia, anæmia, and rheumatoid arthritis, which are said to improve from a residence here. It is still an expensive and fashionable resort, but the accommodations are said to be excellent. There is a fine Kurhaus, two bath houses, where brine, sulphur and pine baths, and brine vapor baths are given. The "milk and whey cure" is also another resource of the place. The number of inhabitants is about 7,000, and there are nearly 6,000 visitors.

The shortest route from England is viâ Cologne to Munich, thence viâ Salzburg to Ischl. It is 1,048 miles distant from Paris.

Although he visited it some years ago, the writer still vividly remembers the beautifully shaded avenue which is one of the features of the place. *Edward O. Otis.*

* Up to this point the text of the original edition has been followed. —E. O. O.

ISINGLASS.—ICHTHYOCOLLA. "The swimming-bladder of *Acipenser Huso* Linn., and of other species of *Acipenser* (Class, Pisces; Order, *Sturiones*)" (U. S. P.).

Isinglass is prepared from these sturgeons, mostly of the tributaries of the Black and Caspian seas where they are very largely consumed for food, by opening and removing their air reservoirs, splitting or slicing them, macerating them to remove their mucous surfaces, and drying; the tripe-like membranes are then rolled in cylinders (staple isinglass), folded in folios (leaf or book isinglass), or done in some other more or less fantastic shape. Its ordinary form in this market is that of "sheets," of irregular size and shape; it is stiff, of a horny or pearly appearance, whitish color, semitransparent, somewhat iridescent, tough, and flexible, but without taste or odor. Isinglass almost completely dissolves in boiling water, the structural character disappearing completely. Besides this, which is generally known as Russian isinglass, and is in this country very expensive, the swimming-bladders of the hake and other fishes are manufactured into sheets and ribbons of thin, light-brownish, gelatinous tissue, known as American isinglass. Its properties are similar to those of the above, but it is darker-colored and not so absolutely free from taste and odor.

Isinglass consists of about ninety-nine per cent. of pure, white, fine, and adhesive gelatin, which forms a jelly with twenty-four parts of water. Its medical and dietetic qualities are identical with those of other pure gelatins, which are frequently substituted for it. Its only medical use is in the preparation of water plasters (isinglass plasters, court plasters, etc.), which are essentially silk or linen cloth, varnished with a thin layer of the isinglass, and backed with some waterproof varnish, like that of gutta-percha or tolu.

Such a plaster is official under the title *Emplastrum ichthyocollæ*.

Japanese isinglass has already been considered under "*Agar-Agar*." *W. P. Bolles.*

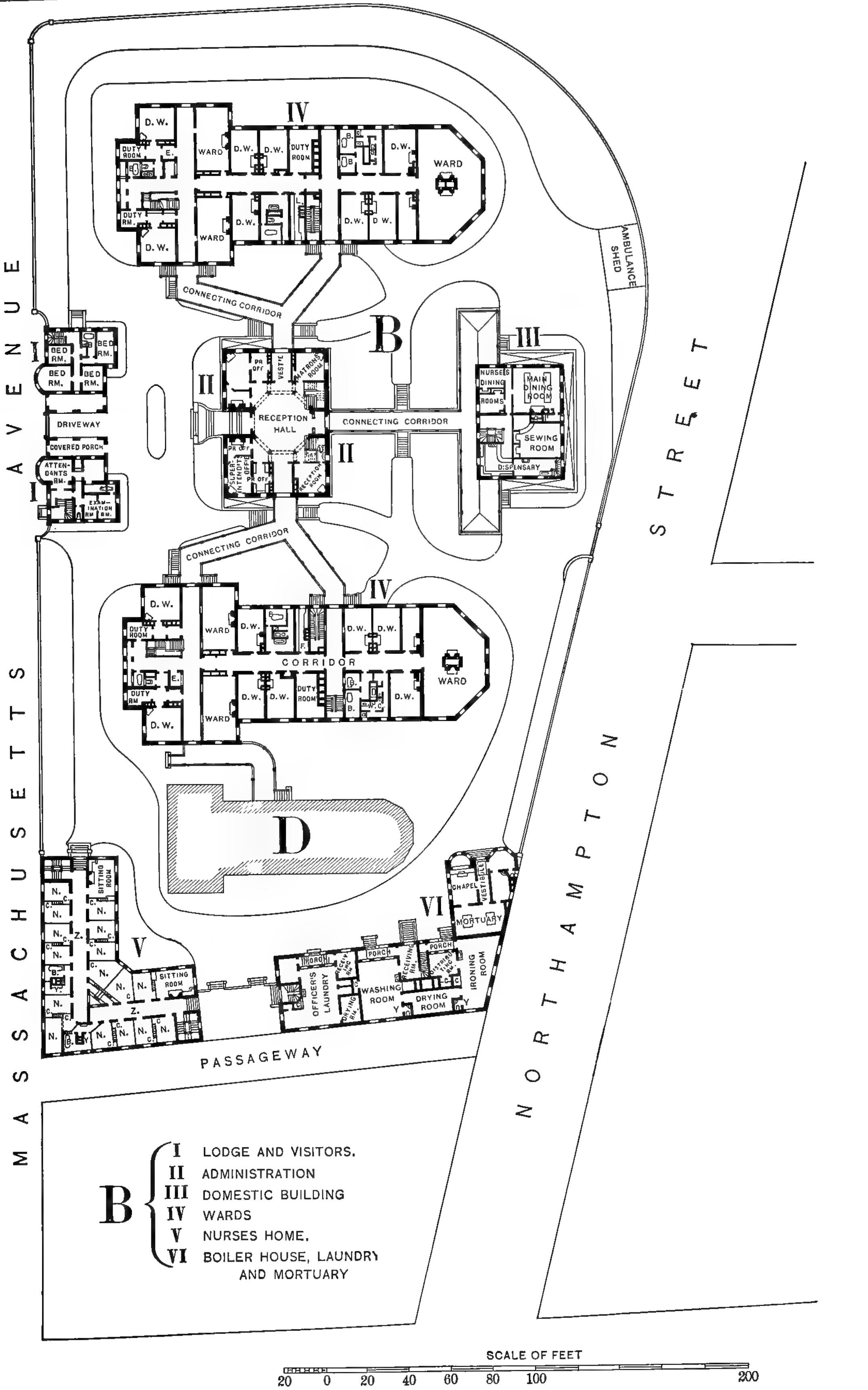
ISOLATION HOSPITALS.—In the present article it is proposed to deal only with such portions of the subject as come within the province of the medical man.

In modern days the term "pest house" no longer expresses the attitude of the public toward the segregation of infectious diseases. The necessity of isolating, in some way or other, individuals affected with such diseases, had already made itself evident in the middle ages. Communities had begun to recognize the advantages of isolation in times of epidemics, but had not learned the value of dissociating it from surroundings calculated to arouse horror or repugnance. The modern aim has been to make the conditions of care and treatment such as to invite the confidence of the public. When a community possesses an infectious hospital in which the interests of the patient are known to be better served than by any other means, a great point has been gained. In Brighton, England, for instance, over eighty per cent. of all persons with contagious disease in the city go to the isolation hospital for treatment. The law in England authorizes the health authorities to insist upon treatment, in hospital, of all persons affected with a contagious disease whose surroundings are such that home treatment would constitute a source of danger to others (Public Health Act, 1875). England was the first country to adopt such a regulation. Sending away the sick member of the family leaves the house free from the irksome quarantine, greatly lessens the expense, and, if the hos-

EXPLANATION OF
PLATE XXXVI.

EXPLANATION OF PLATE XXXVI.

A, Admitting-rooms.
B, Bath-rooms.
C, Closets.
D, Day-rooms.
E, Elevators.
F, Linen-rooms.
G, Supervisor.
H, House Physician's Rooms.
I, Medical Receiving-rooms.
K, Special Wards.
L, Lavatories.
M, Medicine Closets.
N, Nurses' Rooms.
P, Balconies and Terraces.
Q, Splint-room.
R, Recovering-rooms.
S, Students' Rooms.
T, Etherizing-rooms.
U, Surgeons' Receiving and Waiting Rooms.
W, Patients' Wardrobes.
X, Dumb-waiters.
Y, Water-closets.
Z, Connecting Corridors.
D.R, Dining-rooms.
S.R, Surgeons' Rooms.
P.R, Physicians' Rooms.
E.R, Examining-rooms.
D. W, Double Ward.
O.R, Operating-rooms.



PLAN OF BOSTON CITY HOSPITAL, DEPARTMENT FOR INFECTIOUS DISEASES

pital is properly built and managed, gives the patient a better chance of recovery.

The legal right to construct infectious hospitals should be vested in municipal authorities, as part of the regular functions of their board of health. In cases of private institutions for infectious disease it seems proper that some supervision should be exercised by health boards, in order to make sure that the necessary precautions are observed. Such a supervision would also secure protection for the interested parties in actions for damages alleged to be due to infectious hospitals, etc.

Isolation hospitals may be divided into four classes, in accordance with the different conditions which may exist in the community. They are: (1) Relatively large hospitals, serving the requirements of cities; (2) cottage hospitals and those required in small towns; (3) isolation wards or pavilions, in connection with general or special hospitals; (4) isolation hospitals for schools, institutions, etc. In all essential respects the second and fourth classes are virtually the same.

The Site.—This should not be chosen in a thickly settled residential district, nor should it be situated inconveniently far from the population which it is intended to serve. Preferably a site with open space surrounding or adjoining it should be selected; the neighborhood of buildings devoted to large commercial enterprises, which of themselves would check local building of residences, without at the same time giving rise to any nuisance (noise, dust, odors, etc.), often forms a satisfactory spot. Remoteness is to be avoided, as it has been found that the distance at which the danger of infection by air can be eliminated for ordinary infectious diseases, is at most one hundred feet in the case of adjacent buildings. In the City Hospital at Boston it has been shown by experience that the frequency of occurrence of cases in the immediate vicinity of the isolation hospital is less than the average for other parts of the town. The observations made by the Local Government Board on this point (Report of Medical Health Officer, L. G. B., 1881) are very striking. An extensive inquiry made by Thorne-Thorne and Shirley-Murphy brought out the fact that even where large fever hospitals were situated within one hundred feet of dwellings no transmission appeared to take place by means of air or dust in cases of scarlet fever or typhus fever. The distances referred to were: 79 feet, 55 feet, 49 feet, 36 feet, and in one case only 29 feet. A distance of 90 feet between the City of London Workhouse and the Homerton Fever Hospital was apparently sufficient to prevent the occurrence of infection. The Local Government Board lays down 40 feet as a minimum distance between a fever hospital and the nearest point where the public are exposed, the space being called the "sanitary zone." The same distance is enforced as a minimum between various pavilions or outbuildings of the hospital and applies to any outbuilding, temporary extension, etc., none of which must be less than 40 feet from the one nearest to it.

In the case of smallpox hospitals the inquiry showed that where there was an aggregation of only a few cases no instance of the spread of infection through the air occurred. On the other hand, the case of the Fulham Smallpox Hospital (studied by Dr. W. H. Power) furnished very striking evidence of a contrary nature. It was found that a much larger number of cases of smallpox occurred in the vicinity of this hospital than in other parts of the town, and that the majority of these patients lived within the area over which the prevailing winds passed after crossing the hospital property. So far as could be ascertained, this outbreak of smallpox was due entirely to the transportation of the infection by means of air currents. The Local Government Board therefore forbade the erection of a smallpox hospital "(1) on any site where it would have, within one-quarter mile of it as a centre, either a hospital, whether for infectious diseases or not, or a workhouse, or any similar establishment, or a population of 150 to 200 persons; (2) on any site where it would have within one-half mile of it, as a centre, a population of 500 to 600 persons, whether in one or more institutions or in dwelling houses." The Board found it advisable not to sanction the establishment of infectious hospitals unless it was agreed that cases of smallpox should not be received or treated at the same time with other infectious diseases.

Attempts to deal with the outgoing air of smallpox hospitals by passing it through furnaces or by filtering, etc., have not been found to work successfully. Upon this latter point, it should be stated, the observations are not exhaustive. On the other hand, the evidence from the inspection of the provincial institutions in England, where smallpox and other diseases were simultaneously treated, but in separate pavilions, did not show that they were frequently the centres from which infection spread to the neighboring population.

The danger of infection is due less often to the nearness to the hospital than to the way in which it is managed. The wisdom of the Local Government Board in establishing the rule that there shall be erected a close fence six and one-half feet high round the entire grounds of such an institution, is sufficiently obvious.

Capacity of Hospital.—It has been found in England that about one bed per one thousand inhabitants is needed for infectious cases. The requirements of villages and small towns are practically identical, and the necessity of providing for an effective isolation previous to the first case of infectious disease is imperative in order to prevent epidemics. Accommodation somewhat in excess of the ordinary needs of the locality should be furnished, so that recourse to temporary additions may be seldom needed and expense thus saved. This also allows for increased demands owing to growth of population. Accommodation for administrative purposes should be furnished in excess of what is actually required for the wards ordinarily in use, so that it may also prove adequate to the extra demands made upon it in time of epidemic. The minimum requirements, in the case of a village, call for accommodations suitable for isolating four patients—two of each sex.

Arrangement.—The hospital should be so arranged that each disease may be treated in a separate building. In most establishments there are separate pavilions for scarlet fever and diphtheria. In addition to the isolation or observation wards, administration buildings, etc., some provision should be made for the reception of a few smallpox or other pestilential cases, in order to save the expense of maintaining an empty smallpox hospital during the periods of time intervening between epidemics. The convenience to the public of having accommodations for cases of measles and whooping-cough is greatly appreciated, but, unfortunately, such accommodations are provided in only a small proportion of existing institutions. Where tuberculosis is not provided for by special sanatoria, the patients should be received in separate wards or pavilions. In England pavilions for typhoid cases are often provided.

Cost.—For a small cottage hospital (see below), the cost averages from eight thousand to fifteen thousand dollars; for one large enough to accommodate from forty to fifty patients the expense will run from fifty thousand to one hundred thousand dollars. The cost of the maintenance of infectious patients in the Boston City Hospital, was found, for the year 1900, to be $6.24 per week per head, or $22.52 per case (exclusive of antitoxin). In small establishments the cost per patient is higher, and may reach $100. The expense is mainly due to the necessity of providing a relatively large staff, the actual maintenance of the patients costing rather less than in general hospitals.

Plans.—The plans for a cottage hospital recommended by the Local Government Board in their circular of 1895* will be found valuable as a guide. The accommodations comprise: (1) An administrative building with receiving room, quarters for staff, nurses, and attendants, kitchen (if not separately placed); (2) wards; (3) outbuildings, disinfecting chamber, mortuary, laundry, ambulance,

* Eyre & Spottiswoode, London; price one penny.

stables, etc. The municipal disinfection may be operated in connection with the hospital, the arrangement being found to work smoothly.

When for any reason a special hospital cannot be constructed, the next best thing is to secure the use of a

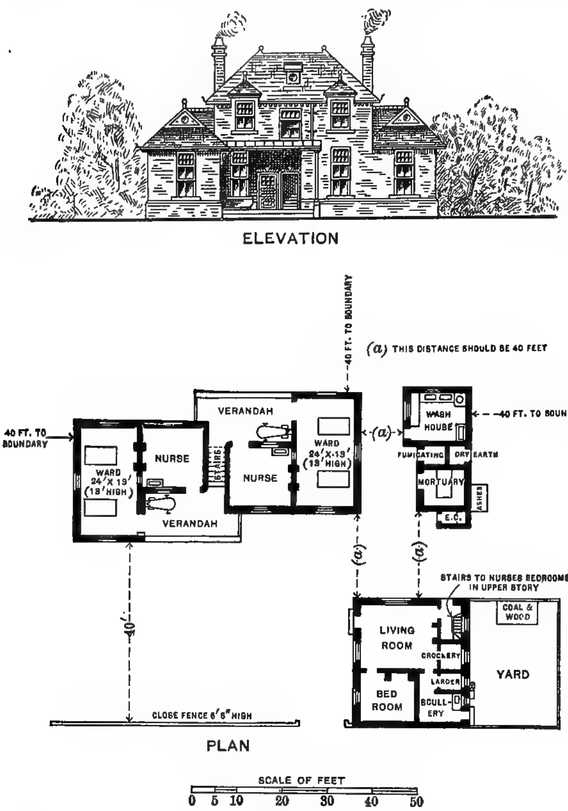


FIG. 2967.—Plan of Cottage Hospital Recommended by Local Government Board.

suitable dwelling which may be placed in the charge of a man and his wife who are willing and competent to take suitable care of cases of this nature.

The minimum requirements for four persons enabling two diseases to be dealt with is shown in Fig. 2967, this would be more efficient if it provided for the separation of sexes, having two separate wards instead of one ward with two beds. The use of the veranda as a means of communication is a good plan, and it will be noticed that the bath is movable. The conditions are as simple as possible, and provide for a dry earth closet system.

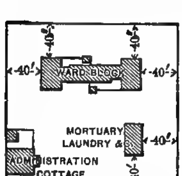


FIG. 2968.—Example of Arrangement of Buildings on a Restricted Site.

The arrangement of buildings upon a restricted site is shown in Fig. 2968.

In Fig. 2969 are shown the plans for two cottage infectious hospitals of from six to ten beds, with a drainage by the water-carriage system. These are satisfactory except in the want of provision for an observation ward.

Fig. 2970 furnishes a plan of a larger hospital, with wards or pavilions for twelve infectious cases. The amount of air space provided per head is 2,000 cubic feet with 144 square feet per bed. The dimensions of the wards are given in the plan.

For cottage hospitals convenient dimensions are: Larger wards, 26' x 22', small 22' x 13', same cubic space (ceilings 14' high); nurses' bedrooms, 15' x 10'; kitchens, 15.5' x 13'; doctor's room, 13' x 9'; matron's, 13' x 11'; two bedrooms, 13' x 11'; servant's bedroom, 9' x 7'; mortuary, 14' x 11'; ambulance shed, 14' x 11'; disinfecting room, 13' x 11'; wash-house, 13' x 11'.

There should be also a discharge room and a store for clean clothes, detached both from the wards and from

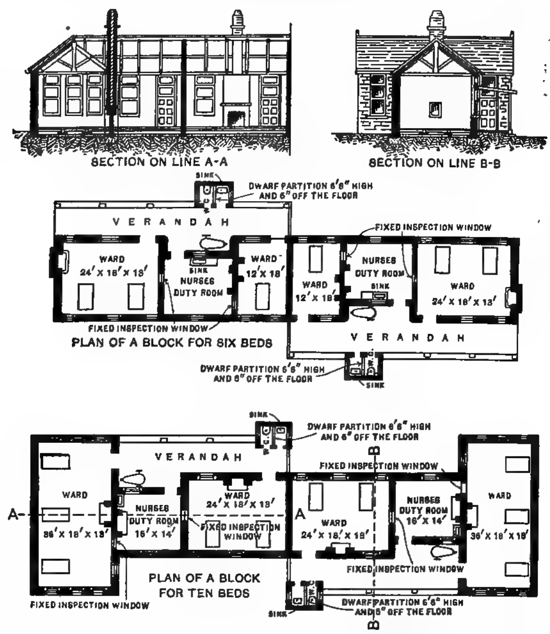
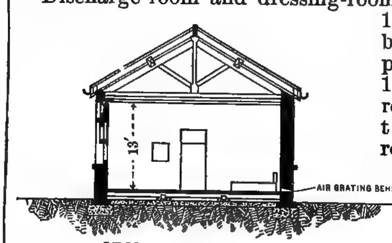


FIG. 2969.—Plans Furnished by the Local Government Board for Two Cottage Infectious Hospitals—one for six and the other for ten beds.

the administration building, for the final disinfection of the patients on leaving the hospital. The dimensions of these rooms are:

Discharge room and dressing-rooms, 8' x 10', 10' x 6', 10' x 11'; shower bathroom, 10' x 4½'; patients' bathroom, 10' x 9'; nurses' bathroom, 10' x 8'; patients' dressing-room, 8' x 10'; nurses' dressing-room, 8'x10'; clothes store, 18' x 8'.



It is essential that com-

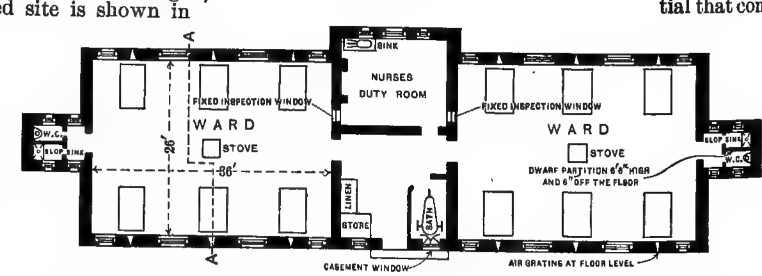


FIG. 2970.—Plan of a Ward Pavilion for Twelve Cases of Infectious Disease. (Plans furnished by the Local Government Board.)

munication between the rooms where different diseases are treated should be by means of outside passages or of corridors which should be open, if the climate permits of

Isolation Hospitals.

it, and in any case separately ventilated from the rest of the building. One of the great difficulties in cold climates is the necessity for economizing space in order

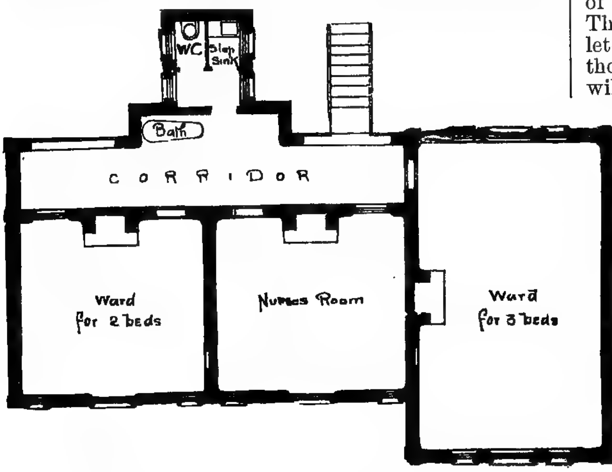


FIG. 2971.—London Fever Hospital, Isolation Building.

to permit of an economic heating arrangement. Abundant facilities for bathing and disinfection by the nurses and attendants are required, no matter how small the hospital may be.

The arrangements for a large hospital for infectious diseases are well illustrated by the plans of the Department for Infectious Diseases of the Boston City Hospital, which is a model establishment of its kind, easily the best on this continent, and certainly equal to any that has been constructed in Europe. These arrangements are shown in Plate XXXVI. It will be noticed that the examination room and attendants' rooms are situated at the entrance, the superintendent's and matron's rooms off the reception hall communicating with all the corridors of the building. The connecting corridors are covered ways exposed freely to the air and open at the sides. The stairways for communication between the blocks are situated outside the buildings so that communication can be had with any flat of the wards without passing through any other wards. The relatively large number of small wards and separate rooms is a special feature. The separate blocks are provided for diphtheria and scarlet-fever patients, with some separate accommodation for those affected with measles or with whooping-cough. It will be seen that an interval of forty feet for all buildings from the street has not been maintained in all instances, but the minimum distance of the wards to the street at no point is less than forty feet.

Construction and Furnishing.—It is specially necessary that the rules as regards simplicity of construction, rounding of corners, use of washable materials for flooring and walls, etc., should be strictly followed in isolation hospitals. The less furniture the better, and that little should be of a kind readily disinfected and not likely to collect dirt.

To facilitate supervision by the nurses the use of glass partitions is very advantageous, as it absolves the attendant from the necessity of spending so much time in the same apartment with the patient. In the new wing for infectious diseases in the Pasteur Institute, the use of glass partitions for individual patients is very general.

Free ventilation is necessary not only for the well-being of the patients but also to reduce the danger of infection by free dilution. A supply of warm fresh air is of course the best available means, and as the buildings are usually detached and widely separated steam heating is most commonly used. Ventilation by the open fireplaces is much in vogue in England.

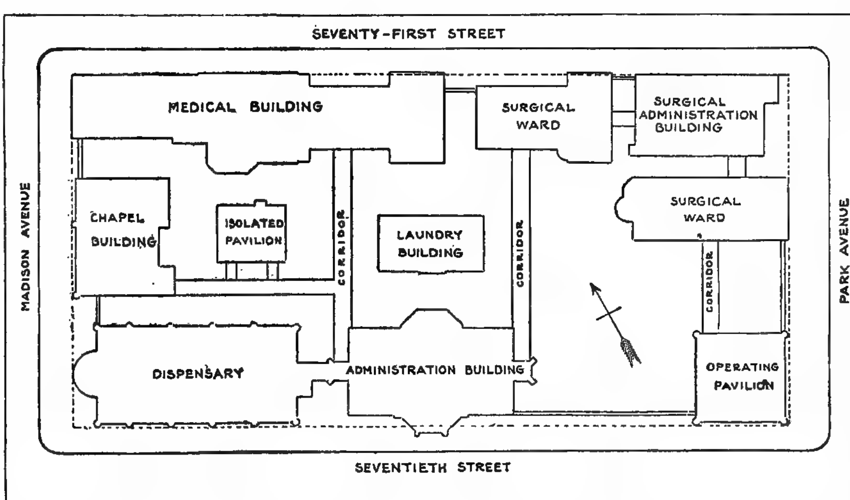


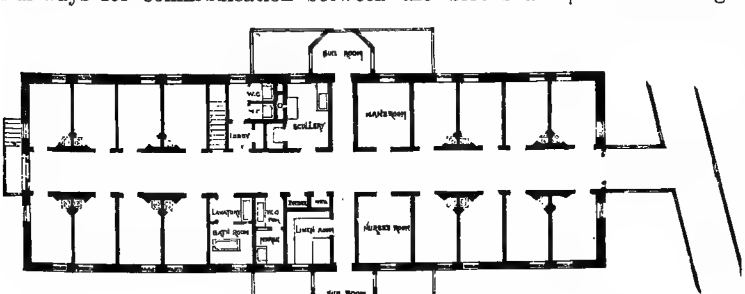
FIG. 2973.—Showing Relations of the Pavilion for Infectious Diseases to the Other Buildings of the Presbyterian Hospital in New York City.

In small hospitals jacketed stoves are very convenient for heating. The apartments of the staff should be ventilated separately.

No special arrangements are called for with reference to lighting, beyond those ordinarily met with in hospitals.

The separation of the kitchen from the wards is necessary, and as a result of this arrangement some difficulty in transportation of the food supplied is likely to occur.

Routine of Admission and Discharge.—On admission patients should be received in the examining-room, and if



—SCALE 16FT TO 1IN—

FIG. 2972.—Massachusetts General Hospital—Isolating Ward.

any doubt exists as to the nature of the case, should be placed in the observation wards until a diagnosis has been made. Their clothes should be sent to be disinfected, and they should receive these disinfected clothes

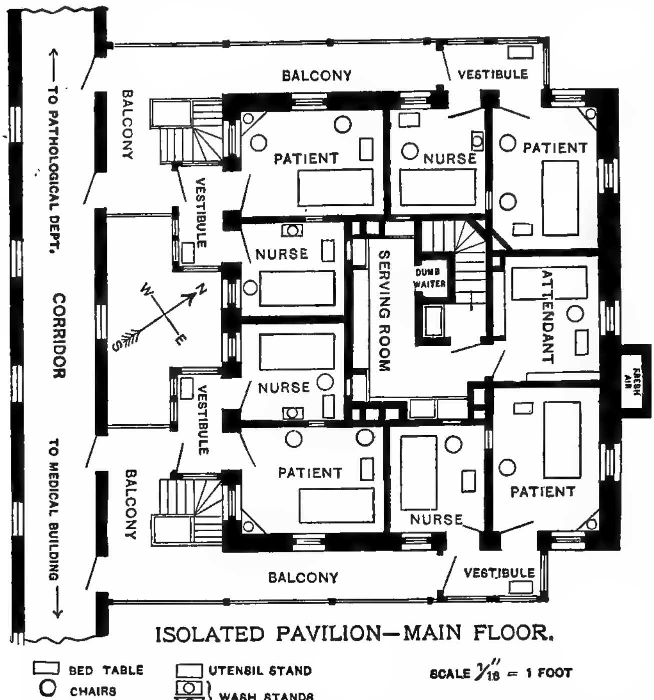


FIG. 2974.—Plan of Isolated Pavilion of the Presbyterian Hospital in New York City.

or a fresh suit upon leaving. Before they take their departure, however, they should be subjected to a series of baths, this being especially necessary in the case of the exanthematous diseases. After the final bath they should dress with clean clothes in a room leading to the outside, so as not to re-enter an infected apartment.

It is of advantage to have a steam sterilizing apparatus upon the premises, though the use of a closed chamber with formalin gives adequate penetration of clothing, bedding, etc.

Whenever possible, a bacteriological examination should be made as a means of regulating the admission and discharge of patients, and for the establishment of the diagnosis in doubtful cases. For the public safety cooperation with a bacteriological laboratory is indispensable.

To prevent dissemination of disease by lay visitors these should be obliged to go through a thorough ritual of disinfection before leaving the premises, and they should be obliged to wear special protective caps and linen dusters, while visiting the wards. Visitors should be admitted only as a matter of urgent necessity and in dangerous cases.

Mortuary.—A suitable place for the care of dead bodies is indispensable. Facilities for proper post-mortem examinations are too often neglected. To prevent the danger of infection being spread by the corpses, and before removal, they should be wrapped in sheets soaked in some disinfectant solution such as sublimate 1:1000, or chloride of lime, one per cent., and the orifices of the body should be plugged by wadding. In case of transportation to a distance, a galvanized iron box, hermetically soldered, should enclose the coffin.

Isolation Departments in General Hospitals.—These are now provided in connection with all of the modern hospitals. As it is not contemplated to treat many cases at any one time, a number of small separate wards give the best accommodation, and, generally speaking, wards of one or two beds only are needed. The amount of accommodation for nurses in these wards must be relatively greater than in the case of an isolation hospital, and provision for separate attendance on each different case should be made. The building must be situated at a sufficient distance (at least forty feet), from any other building, and as far as possible from the surgical wards; location near the mortuary or laundry is preferable. It should not communicate directly with any part of the hospital, but should be accessible only through open corridors or bridges. Communication between the different wards of the isolation pavilion should be by means of a balcony or an open vestibule, rather than by internal passages. Food, medicines, clothing, etc., should be sent with special precautions, and nothing should be returned unless carefully disinfected. The services of an attendant apart from the nurses will be necessary even in the case of a small establishment, in order to prevent communication between this department and the hospital proper. The ventilation of each ward and room in the isolation pavilion should be strictly separate. Examples of isolation wards are shown in the accompanying figures (Figs. 2971, 2972, 2973, and 2974). The number of beds required is about four per cent. of the total population of the hospital.

The destruction of garbage and refuse by cremation is an essential in any well-conducted hospital. A number of small garbage and refuse destructors are on the market, but only a few of them are found to give very satisfactory results. Destruction of the bodies of persons dying of infectious disease may be called for in connection with severe epidemics, and a crematory is practically indispensable in connection with the isolation hospital of a well-equipped quarantine station. *Wyatt G. Johnston.*

BIBLIOGRAPHY.

The publications of the Local Government Board, 1880, 1883, 1895, referred to above, contain valuable data. See also Burdett's Cottage Hospitals (with plans); MacNeill's Epidemic and Isolation Hospitals; Galton on Hospital Construction; Notter and Firth: Hygiene; Weyl's Handbuch f. Hygiene, Band 5; Ruppel on Hospital Construction; Mercke on Hospital Management, with very full plans of many leading hospitals.

ITCH-MITE. See *Arachnida.*

IVY.—*English, Black, Creeping,* or *Common Ivy. Hedera.* The herbage and fruit of *Hedera Helix* L. (*H. poetica* Salisb., fam., *Araliaceæ*). The gum resin exuded by the stem is also used.

This well-known and highly ornamental evergreen is native of Europe and temperate Asia, and is cultivated in all countries having a suitable climate. The leaves are stoutly petioled, from three to six inches long, and mostly of greater breadth, entire or palmately three- to five-lobed, rounded or cordate at the base, acute at the summit, smooth, very dark-green, very thick and coriaceous, somewhat aromatic and of an astringent and disagreeably bitter taste. The poisonous fruits are in long-peduncled, panicled umbels and are five-pyrenate berries, smooth, black, and internally mealy. They have a terebinthinate odor when bruised and a pungent, somewhat sour, terebinthinate taste. The leaves contain a little volatile oil, tannin, and the glucoside *helixin*, which yields *helixigenin*. The fruit contains a bitter-sweet resin in the pulp, and several specific principles in the seeds, namely *hederic acid* ($C_{16}H_{26}O_4$) and *hederotannic acid*. A bitter body, *hederin*, has been reported, but its nature is unknown. It has been claimed that it is identical with the hederotannic acid, but this appears unlikely. The emetico-cathartic and poisonous properties have been proven by Joanin to reside in the hederin.

Ivy leaves have been used, bruised into a poultice-like mass and in other forms, as a parasiticide and a stimulating application to cutaneous ulcers and eruptions. They are also used internally in doses of gr. xv.–xxx., in various diseases and wholly unscientifically. The fruits are emetico-cathartic and are doubtless effective as a nauseating diaphoretic, and have thus been used in febrile states. The gum resin is used as an astringent internally, and externally for the same purposes as the leaves.

Henry H. Rusby.

IVY, GROUND. See *Labiatæ*.

IVY, POISON.—Rhus Toxicodendron, Mercury, Poison Oak. "The fresh leaves of *Rhus radicans* L. (fam. *Anacardiaceæ*)," U. S. P. The general account of this plant will be found under the title *Poisonous Plants*. It is introduced here merely to refer to its use, chiefly in the form of the tincture, in doses under two minims and usually minute, in the treatment of "paralysis, skin diseases, and incontinence of urine." Those physicians who are not gifted with a homœopathic imagination have failed to find its use warranted, and it will probably be dropped from the next edition of the Pharmacopœia. *Henry H. Rusby.*

IXODES RICINUS. See *Arachnida*.

IXTLAN* SPRINGS, MEXICO.—Within the municipal limits of Ixtlan, state of Michoacan, Mexico, there are a large number of mineral springs generally known as "Pozos Hervideros," or in English "Boiling Springs." The temperature of the water is quite high and the odor of sulphurous acid is very marked. People suffering from syphilis and rheumatism, and especially those suffering from the chronic manifestations of these diseases, resort to the springs in large numbers in order to take the baths, in spite of the very unsatisfactory arrangements existing for the purpose.

In Mexico Dr. Zuñiga has made an analysis of these waters, and he states that their composition is as follows, per litre: Carbonic acid, 0.0075; carbonate of lime, 0.0257; sulphate of lime, 0.0210; chloride of magnesium, 0.0135. He therefore very properly places them in the group of simple thermal springs.

N. J. Ponce de Léon.

JABORANDI.—Pilocarpus. "The leaflets of *Pilocarpus Selloanus* Engler (Rio Janeiro Jaborandi) and of *Pilocarpus Jaborandi* Holmes (Pernambuco Jaborandi) (fam. *Rutaceæ*)," U. S. P. Just what the official definition ought to include is not clear, but certainly the first named of these two species is a very inferior drug, and its admission is excusable only on the ground that the market is often devoid of anything better. Its preparations should in all cases be specifically so labelled, and larger doses given. Better still, every preparation of jaborandi should bear a statement of its alkaloidal percentage. The British Pharmacopœia authorizes only the second species. The genus *Pilocarpus* Vahl. contains about fifteen species, all tropical American shrubs, having impari-pinnate leaves, occasionally of but one leaflet. A number of them are known to possess alkaloids similar to those of the official article, and to possess similar properties. It is not at all improbable that others are even fully equal to *P. Jaborandi*. This species occurs in the Pernambuco region, and is exported thence. *P. Selloanus* grows in southern Brazil and Paraguay. Since the better drug will doubtless be alone retained in the next edition of the United States Pharmacopœia, it is here described.

Very shortly and stoutly petioluled, the blades 6 to 12 cm. (2½ to 5 in.) long and 2 to 4 cm. (¾ to 1½ in.) broad, oblong or oval, occasionally a very little narrower above or below the middle, usually slightly inequilateral at the base, blunt and retuse at the summit, entire and thinly revolute at the margin, yellowish- or brownish-green, smooth and slightly shining, especially underneath, thick and coriaceous, not much wrinkled, the reticulate venation prominent on both surfaces, especially underneath; strongly pellucid-punctate; somewhat peculiarly aromatic when crushed and warmed in the hand; taste bitterish, somewhat salty, aromatic, later somewhat pungent and sialagogue.

Leaves which are very much smaller, those of a dull or gray-green, those markedly narrowed in the lower half and those tomentose underneath are from unofficial species.

Even the powder is distinguished by a distinct yellowish-green tint, quite different from the dull green of the Rio Janeiro or Paraguay species. The distinction of the better drug is in this case of unusual importance, and the physician may well supplement the knowledge of the pharmacist, who is usually very ill-informed concerning it. The Rio Janeiro leaflets are narrower and much more frequently oblanceolate than lanceolate or oblong. They are not so thick or so veiny and are of a dull but strong green. The Paraguay jaborandi (from *P. pennatifolius* Lem.) is of a gray-green, and the leaflets are mostly oblong, otherwise like the last. They are almost worthless. Very poor also are the velvety-hairy leaves of *P. trochylophus* Holmes. *P. spicatus*, "Aracati jaborandi," has unifoliolate leaves and is quite worthless. Those of *P. microphyllus* Stapf, with obovate, strongly emarginate leaflets, acute at the base and only one to one and one-half inches in length, are of a quality almost equal to the best, and their introduction to this definition, in place of *P. selloanus*, appears justifiable.

Constituents.—The one-half per cent. of volatile oil is by no means inactive, but attention has not been attracted to it. Alkaloids to the extent of about three-

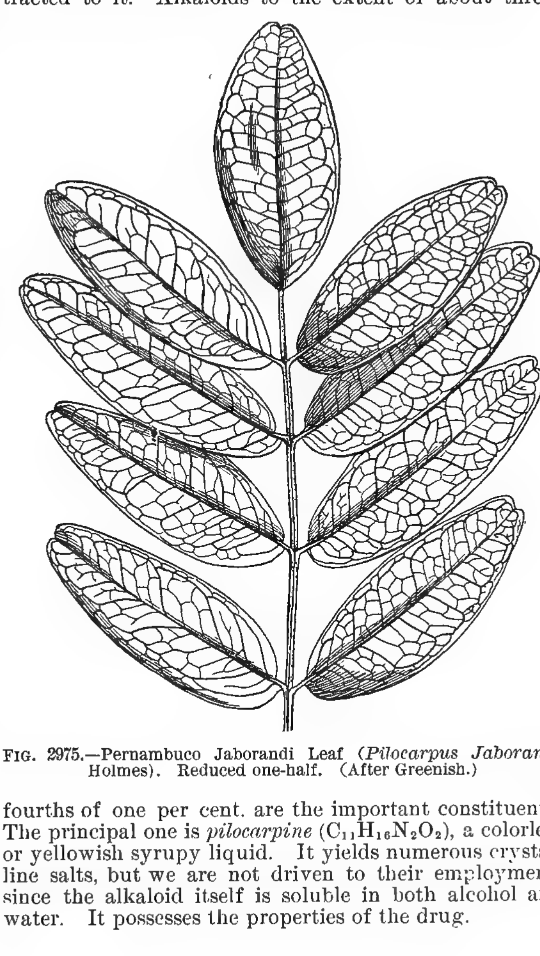


Fig. 2975.—Pernambuco Jaborandi Leaf (*Pilocarpus Jaborandi* Holmes). Reduced one-half. (After Greenish.)

fourths of one per cent. are the important constituents. The principal one is *pilocarpine* ($C_{11}H_{16}N_2O_2$), a colorless or yellowish syrupy liquid. It yields numerous crystalline salts, but we are not driven to their employment, since the alkaloid itself is soluble in both alcohol and water. It possesses the properties of the drug.

* Also spelled "Yxtlan."

Pilocarpidine ($C_{10}H_{14}N_2O_2$) is also present, and can be artificially produced from the former. It is soluble in water. Its action differs in slight particulars from that of pilocarpine.

Jaborine ($C_{22}H_{32}N_4O_4$) is also a derivative of pilocarpine. It is yellowish and syrupy, or becomes a soft solid. It is soluble in alcohol, but only slightly in water. Although its action is opposed to that of the others, there is so little of it as not to interfere greatly when the entire drug, or a preparation which certainly contains all its constituents, is used.

Action.—In almost every particular jaborandi is directly antagonistic to belladonna. Its essential action is to stimulate the secretions, with the exception of those of the kidney and the mammary gland. In the liver, the production of sugar is increased, but not that of the bile. The secretions most affected are those of the skin, the salivary glands, and the pancreas, but those of eyes, ears, stomach, and intestine all share markedly in the result. Salivation is the first to appear, and diaphoresis begins as that diminishes. The salivary, and especially the sudorific, increases are the greatest known in the case of any drug, and are sometimes quite phenomenal. The watery portion is most increased, but there is also some increase in the solid portion. The mode of operation appears to be the stimulation of the nerve endings in the gland. The production of leucocytes is notably increased. There is hyperæmia of the tissues whose activity is increased, but this seems secondary to, and dependent upon, the former. Through the increased heat radiation there is a fall of temperature. The powerful contraction of the pupil, also through stimulation of the nerve endings, illustrates what takes place in many other involuntary muscles. The blood-vessels are not thus affected, so there is not the increase of blood pressure that we should expect. Neither is the heart so affected, but the terminal filaments of the vagus in this organ are usually stimulated and the movements of the heart as a whole are slowed. This effect is, however, quite uncertain. Nausea is apt to follow the other symptoms after large doses have been taken.

Use.—The uses of jaborandi, though already very important, are by no means developed, especially that as a stimulant to intestinal digestion, through increased pancreatic secretion. It will probably, in future, have a wide and important use in this direction. Its present use is almost wholly as a sudorific, and it seems to work well in all cases in which increased perspiration can be of service. It is especially valuable in removing dropsical accumulations, and, while not itself directly affecting the existing disease, the improved condition is often the cause of complete recovery. It is also of special value in uræmia, in which condition it washes out from the skin accumulated waste and clears the way for further depurative action. By early relieving congestion, in case of a threatened cold, the latter can be averted, but the patient must be carefully protected. It promotes to a marked extent the nutrition of the nails and hair, as well as of the skin generally, and its use in cutaneous diseases is a still largely unworked field. It is often productive of great benefit in promoting a new growth of hair, even when locally applied. The hair at the same time becomes oily and is apt to become darker. Some well-known and curious accidents in producing dark spots upon white hair have occurred. The alkaloid is often used locally as a substitute for eserine in the eye, while its internal use relieves congested states of that as of other organs.

Several cautions are to be observed in the use of jaborandi. It may produce, and will increase the tendency to, abortion. Ordinarily, small doses are to be preferred, as there is a great tendency to reaction after its use, mental as well as great physical depression, and lack of secretion. The jaborine content should be avoided as far as possible. Since this is insoluble in water, but soluble in alcohol, while pilocarpine is soluble in both, a weak alcoholic menstruum is to be preferred, and commonly the use of the alkaloid, carefully prepared, is even better. The Pharmacopœia provides a fluid extract, made with diluted alcohol, the dose of which is 0.6–4 c.c. (♏x.–lx.). The dose of pilocarpine is 0.01–0.02 gm. (gr. $\frac{1}{6}$–$\frac{1}{3}$). For ocular instillation, a one-per-cent. solution is to be preferred, and one or two minims will be found sufficient.

Henry H. Rusby.

JACKSONVILLE, FLORIDA.—The city of Jacksonville, the largest in Florida, is situated about 25 miles from the mouth of the St. John's River, on its left bank. It contains 30,000 or more inhabitants, which are largely added to during the winter months by transient visitors and invalids seeking a mild and salubrious climate. The city is well laid out with wide and well-shaded streets and parks, and offers all the advantages to be expected from a city of this size: good public schools, a library, opera house, public halls, and churches of various denominations. There is a good water supply from artesian wells, and a system of sewerage introduced under the direction of the late Colonel Waring. The death rate is low. There are good shell roads leading out of the city which afford good driving and cycling. The various excursions on the river are also attractive.

If one desires to spend the winter in a city in a mild and sunny climate, Jacksonville offers many advantages. There are excellent and abundant accommodations of all kinds, from the hotel of five hundred guests to a variety of smaller boarding- and lodging-houses. Unfurnished cottages can also be obtained. The winter climate is mild and equable, and of medium moisture.

The following table gives the climatic data for the five winter months—November to March inclusive.

Climate of Jacksonville, Fla. Latitude, 30° 20′; Longitude, 81° 39′. Period of Observation Twelve Years.

	November.	December.	January.	February.	March.	Year.
Temperature—						
Average or normal	61.7°	55.8°	55.8°	58.1°	62.7°	69.2°
Average daily range	15.6	17.0	16.7	16.4	17.4	
Mean of warmest	70.9	66.4	64.9	68.5	73.6	
Mean of coldest	55.3	49.4	48.2	52.1	56.2	
Highest or maximum	84.0	81.0	80.0	83.0	88.0	
Lowest or minimum	30.0	19.0	24.0	32.0	31.0	
Humidity—						
Average relative	74.8%	73.7%	74.6%	70.6%	65.4%	72.0%
Precipitation—						
Average in inches	2.95	2.89	3.28	3.45	3.13	54.68
Wind—						
Prevailing direction	N. E.	N. E.	N. E.	N. E.	S. W.	N. E.
Average hourly velocity in miles	6.5	6.0	5.8	6.9	7.9	6.7
Weather—						
Average number clear days.	9.8	10.2	9.0	9.7	12.7	123.2
Average number fair days.	11.1	12.0	12.8	10.4	13.0	156.7
Average number clear and fair days	20.9	[illegible]	21.8	20.1	25.7	279.9

Edward O. Otis.

JALAP.—Jalapa. The tuberous root of *Exogonium purga* (Wend.) Linal. (*Ipomœa F.* Hayne; I. *Jalapa* Schiede and Deppes—fam. *Convolvulaceæ*).

This is a perennial, herbaceous twiner with numerous slender, twisted and furrowed, moderately branched stems, arising from ovoid, pear-shaped, or subspherical tubers, these often clustered or tangled together by roots and rhizomes. The flower is merely a large, handsome, rose-colored "morning glory." It is a native of Eastern and Central Mexico, from one town of which it has received its name (Jalapa). Jalap was known and brought to Europe as early as the beginning of the sixteenth century, if not before. Its botanical source was demonstrated first in the early part of this century, by Dr. Coxe, of Philadelphia.

The collection of jalap is carried on without much regard to season. The tubercles are dug up and dried by artificial heat, the smaller ones entire, the larger scored (usually lengthwise), or split or sliced. The heat employed is often sufficient to break the starch granules,

and so, when dry, the texture is often horny, on account of the hardened starch mucilage, irrespectively of the amount of resin contained. The cultivation of jalap is in its infancy.

DESCRIPTION.—The jalap tubercles are in part described above; the Pharmacopœial description is as follows: "Napiform, pyriform, or oblong, varying in size; the larger roots incised, more or less wrinkled, dark brown, with lighter-colored spots, and short, transverse ridges; hard, compact, internally pale grayish-brown, with numerous concentric circles composed of small resin cells; fracture resinous, not fibrous; odor slight, but peculiar, smoky and sweetish; taste sweetish and acrid.

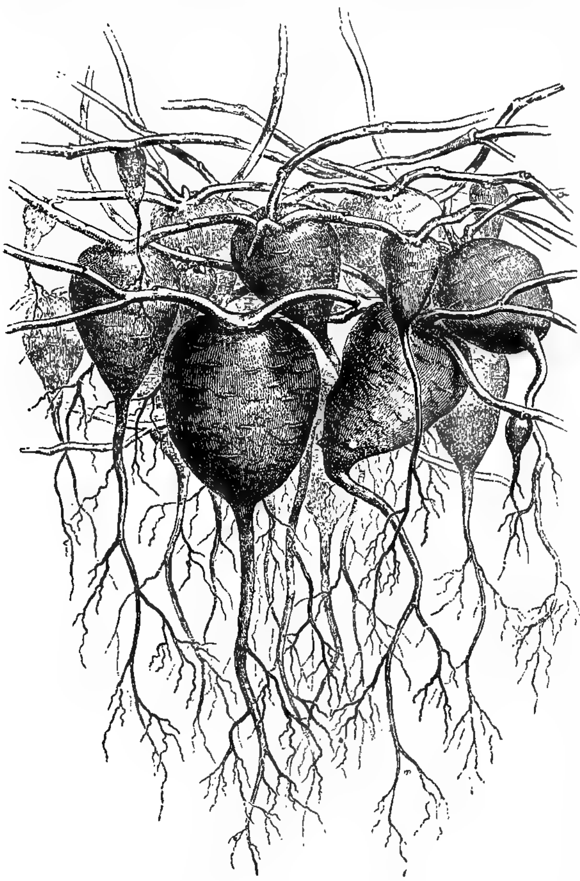


FIG. 2976.—Jalap Roots. (Baillon.)

"On exhausting 100 parts of jalap with alcohol, concentrating the tincture to 40 parts, and pouring it into water, a precipitate of resin should be obtained, which, when washed with water and dried, should weigh not less than 12 parts, and of which not over ten per cent. should be soluble in ether."

It is said that this requirement of twelve per cent. of resin is excessive and difficult, if not impossible, to attain in the commercial drug. Probably eight or nine or, at most, ten (as in the British Pharmacopœia) per cent. would be a reasonable requirement. Cultivation is an important factor, as under it twenty per cent. of resin has been produced. The dried tubercles of the market have shrunken and shrivelled considerably, and are usually much more acute than represented in the above cut of living roots.

COMPOSITION.—Jalap contains a large amount of sugar and of starch, substances which contribute to its taste and texture, but have no further value. Its active principle is a composite *resin*, the quantity of which determines the value of the article. This crude substance consists of two resins, both of which are soluble in alcohol, but only one of which (the most considerable) is also soluble in ether; the insoluble portion is called *convolvulin*. It is regarded as a glucoside. Merck gives the formula as $C_{31}H_{50}O_{16}$ and the dose as gr. i.–iij. It is only partly soluble in water. It is converted by alkalies into convolvulinic acid, which is active in three times the dose of the convolvulin. The jalapin is also active, and is the principal constituent of scammony. The crude resin of jalap is official (*Resina Jalapæ*, U. S. P.), and in common use.

ACTION AND USE.—Jalap is one of a considerable number of active cathartics whose energy either lies in their resinous contents or is at present inseparable from them. Of these, however, it is one of the mildest and most uniform, and probably, in consequence, one of the most frequently employed. In full doses it produces free hydragogue catharsis, with more or less, but generally not excessive, nausea and griping.

It has been traditionally used as an adjuvant to calomel. Of its action upon other organs than the stomach and bowels but little can be said. It is doubtful whether much of it is absorbed. It will not act if injected hypodermically.

ADMINISTRATION. — Powdered jalap is frequently given, and contains so little woody tissue that it is a very good form. Dose, 1–1.5 gm. (gr. xv.–xx.); as a drastic purgative sometimes twice as much. The resin is about five or six times as active as the crude powder. The compound powder of jalap (Pulvis Jalapæ Compositus) is frequently of use in anasarca, when a combined effect upon the kidneys and intestines is desired. It consists of jalap, 35 parts, and cream of tartar, 65. Dose, a gram or so twice a day. There is also an official alcoholic extract, the dose of which is gr. ij.–viij. *Henry H. Rusby.*

JAMAICA.—Jamaica, a British colony, is an island in the Caribbean Sea, lying between 17° 43′ and 18° 32′ North Latitude, and 76° 11′ and 78° 20′ 50″ West Longitude. It is about 90 miles south of Cuba, nearly 5,000 miles from Southampton, and a little more than 1,400 miles from New York. It is 144 miles in length and from 21½ to 49 miles in width. The surface of the island is crumpled up into a central mountain range with numerous outlying spurs. The highest points of this range, contrary to the usual rule, are in the eastern portion, whence the surface slopes irregularly toward the west, where the only level parts of any extent are found. There is one principal range, called the Blue Mountains, running east and west through the centre of the island, and from this secondary ridges run north and south, themselves giving off other and shorter spurs in a direction parallel to the central range. The highest point is Blue Mountain Peak which rises to an elevation of 7,360 feet; Catherine's Peak has an altitude of over 5,000 feet; and there are several others, varying in height from 4,000 to 5,000 feet. The island is in general well watered, the abundance of rivers and springs in most parts giving plausibility to the generally accepted interpretation of the name, Jamaica, which is believed to have signified in the aboriginal tongue the "Isle of Springs," or the "Land of Wood and Water."

It is difficult, in a brief article of this nature, to describe satisfactorily the climate of Jamaica, as, owing to the diversity of elevation and other causes, it varies greatly in different parts of the island; in some parts it is hot, in others temperate and even cool; in some it is dry, in others the rainfall is very great; and indeed the only characteristic common to all the varying climates of Jamaica is equability. Thus, at the sea-coast the average temperature is 78° F. (the extreme range for the entire year being only 35° F.), while on the mountains at an elevation of between 4,000 and 7,000 feet the mercury ranges from 40° to 74° F., occasionally falling, on the summit of the highest peak and in midwinter, even to the freezing-point.

Meteorological Data for Points of Different Elevation in the Island of Jamaica for 1899.*

Hope Garden, Elevation 600 Feet.

Months.	Mean average temperature.	Maximum temperature.	Minimum temperature.	Range.	Humidity.	Rainfall in inches.
January	71.4°	85.0°	65.4°	19.6	81.5%	1.47
February	....	....	....	....	....	....
March	71.9	83.3	65.7	17.6	68.5	1.49
April	76.5	84.2	66.2	18.0	68.5	2.75
May	78.1	87.5	66.9	20.6	70.5	5.23
June	79.6	89.6	71.1	18.5	71.0	1.99
July	80.9	91.8	69.7	22.1	65.5	2.82
August	81.3	91.3	69.6	21.7	67.5	1.39
September	79.2	89.2	70.5	18.7	77.0	5.37
October	76.7	85.5	69.3	16.2	82.5	31.73
November	76.2	85.3	68.2	17.1	83.5	16.93
December	73.2	83.9	63.9	20.0	78.0	10.06

Stony Hill Reformatory, Elevation 1,400 Feet.

Months.	Mean average temperature.	Maximum temperature.	Minimum temperature.	Range.	Humidity.	Rainfall in inches.
January	71.8°	81.3°	63.4°	17.9	89.5%	1.47
February	72.0	82.9	63.0	19.9	....	0.55
March	72.4	81.2	64.4	16.8	83.5	2.36
April	72.5	82.6	63.4	19.2	90.5	3.79
May	75.8	85.2	64.3	20.9	88.5	5.79
June	75.9	86.8	66.0	20.8	83.0	3.93
July	77.8	87.6	67.6	20.0	76.0	5.21
August	78.0	88.3	67.7	20.6	81.0	1.64
September	76.8	87.1	67.5	19.6	79.5	9.99
October	74.8	84.0	66.5	17.5	81.0	34.93
November	73.4	84.9	65.6	19.3	73.0	19.41
December	71.4	82.1	61.8	20.3	84.0	9.23

Mandeville, Elevation 2,100 Feet.

Months.	Year.	Maximum temperature.	Minimum temperature.	Range.	Days above 80°.
December	1900	81.7°	65.3°	16.4	6
January	1900	81.0	61.4	19.6	1
February	....	81.1	60.2	20.9	3
March	....	80.6	61.7	18.9	4
April	....	85.7	60.0	25.7	11
May	....	81.7	64.3	17.4	5
June	....	81.0	67.8	13.2	1
July	....	81.8	68.0	13.8	6
August	....	82.7	67.2	15.5	12

Hill Gardens, 4,907 Feet.

Months.	Mean average temperature.	Maximum temperature.	Minimum temperature.	Range.	Humidity.	Rainfall in inches.
January	60.3°	67.4°	54.3°	13.1	86.0%	14.54
February	60.6	67.7	53.9	13.8	84.0	1.04
March	69.4	65.6	53.5	12.1	85.5	5.16
April	61.3	66.6	55.1	11.5	84.5	4.21
May	63.5	69.2	56.6	12.6	81.0	4.54
June	64.9	70.4	58.4	12.0	82.5	1.78
July	65.0	70.8	57.5	13.3	79.5	2.32
August	64.8	74.2	57.5	16.7	79.5	.76
September	65.4	72.5	59.8	12.7	85.0	5.39
October	63.0	68.0	58.6	9.4	89.5	41.22
November	62.7	67.7	58.0	9.7	88.5	44.09
December	60.5	66.5	54.4	12.1	83.5	16.90

*Through the kindness of Prof. W. H. Pickering, of the Harvard College Observatory, I have obtained the Jamaica weather report for 1899 from which the following meteorological data have been compiled for points of various elevation in the island; and to this are also added the maximum and minimum temperatures of Mandeville, observed by Professor Pickering during his nine months' residence there.—E. O. O.

Blue Mountain Peak, 7,423 Feet High.

Time of observation.	Temperature.	Maximum.	Minimum.	Rainfall since last observation.
February 1st, 11:30 A.M.	56°	69.9°	38.8°	24.87
March 1st.	56	68.9	39.8	4.15
April 1st, 11:30 A.M.	58	64.9	40.8	8.10
June 1st, 10:30 A.M.	65	69.9	44.8	8.23
June 30th, 11:15 A.M.	58	70.9	46.8	5.45
July 31st, 11 A.M.	59	71.9	46.8	6.05
August 31st, 10 A.M	67	74.9	44.8	6.45
October 2d, 1 P.M.	59	73.9	43.8	12.90
November 1st, noon	56	70.9	42.8	15.95
November 30th, 11:30 A.M.	69	70.9	46.8	48.16
December 31st, 11:45 A.M.	67	71.9	41.8	25.45

The most striking peculiarity of the climate of Jamaica is its variety combined with equability. A ride of a few miles into the hills will bring one from the torrid zone to the temperate—from an average temperature of nearly 80° F. to one of 65° or 70° F. But whatever district one may select, whether a warm or a cool one, he will find the temperature very nearly constant, the extreme range for any one month being seldom over 25° F., while that for the entire year at Kingston is but 35° F., and in some parts of the island the excursions of the mercury are even more restricted than this. The humidity in every part of the island is comparatively high, but varies considerably in different localities. Jamaica, indeed, enjoys all the advantages, in respect to uniformity of temperature, of island climates in general, while the differences in elevation and in exposure to, or protection from, the prevailing trade winds give to it the pleasing diversity, as regards temperature, humidity, and rainfall, of the most temperate of continental climates.

There is, as a rule, less rain in Kingston than in most of the other parts of the island, the trade winds being drained of their moisture by the mountains to the north and east of the city. The heaviest precipitation occurs in the Parish of Portland, which forms the northeastern extremity of the island. There are two principal rainy seasons, namely, in May and October, but there is usually more or less rain all through the summer months; in the winter season in the neighborhood of Kingston the precipitation is very light. The rain usually comes in heavy showers of only a few hours' duration, and the days during which the sun does not shine at all are very rare. It is always possible to tell when rain is coming, as it can be seen, quite a while before its arrival, advancing from the mountains, thus giving one ample time to get under cover before the downpour begins. This is fortunate for the visitor, as a wetting is one of the three things that an unacclimated person in the tropics must avoid, the other two being exposure to the direct rays of the noonday sun and to the cool night air.

The population of Jamaica, according to the census of 1891, is 639,491, an increase of about 60,000 since the census of 1881, and of 133,000 since that of 1871. The total estimated population on the 31st of March, 1899, was 730,725. The capital and chief city is Kingston, the largest and most important as well as the healthiest seaport town of the British West Indies. It is a city of 50,000 or more inhabitants, situated on gently sloping ground on the shores of a large land-locked harbor. The land on which the city lies is a gravel bed, and as it has a slope to the sea of about ninety feet to the mile the natural drainage is excellent. The water supply is drawn from two rivers at a distance of several miles from the city, and, as regards freedom from contamination, is above reproach.

The Myrtle Bank Hotel, pleasantly situated on the shore of the bay near the outskirts of the city, affords excellent accommodation for visitors, and there are also several other hotels and a number of boarding-houses where one may live modestly and at moderate expense. Another well-built hotel, having accommodation for one hundred and fifty to two hundred guests, is at Constant

Spring, six miles from Kingston, near the foot of the mountains which enclose in the form of an amphitheatre the Liguanea plain. The hotel lies at an elevation of five hundred feet above Kingston, and from it is had a fine view of the harbor and Caribbean Sea beyond. The temperature here is uniformly ten to twelve degrees lower than that of the city. Other comfortable hotels are found in Santiago de la Vega, usually called Spanish Town, which was formerly the capital of the island, and at Moneague, a charming spot in the Parish of St. Ann, on the northern slope of the central mountain range. Mandeville, a beautiful little place in the hills, celebrated for its delicious oranges, is a favorite resort for Jamaicans from Kingston and other coast towns who may feel the want of a change of air and scene. There are a hotel and several boarding-houses here, but intending visitors must take the precaution to apply in advance if they would be sure of being well suited. Among the coast towns on the north side of the island, Lucea, St. Ann's Bay, and Montego Bay are the most important from the point of view of the tourist and the invalid. In these and the other towns of the island visitors may find accommodation at various boarding- and lodging-houses about which, however, it would be wise to inquire before making a selection, as they are of varying degrees of excellence and the reverse.

At Port Henderson, on the southern shore of the island, at the entrance to Kingston harbor, there is a saline-calcic spring which is said to possess tonic properties of no mean order and is much resorted to as a bath by convalescents and others from the neighboring districts. There is also a good beach for sea-bathing. There are several buildings here in good order, but the accommodations are not extensive. The place can readily be reached, however, by a steam launch from Kingston in forty-five minutes. No analysis of the water of the spring has ever been published.

The diseases for the climatic treatment of which Jamaica is well suited are bronchitis, catarrhal affections of the respiratory passages, Bright's disease, rheumatism, various forms of dyspepsia, and nervous prostration. All parts of the island are naturally not suitable for the treatment of all these affections, but for each one a locality exists where the patient can find the climate especially adapted to the necessities of his particular disease. Respiratory affections especially do well in this mild and equable climate, as may be judged from the records of one of the life insurance companies doing business on the island, which show that the company lost but one life from diseases of the respiratory organs (bronchitis) during a period of thirty-five years. Patients suffering from these troubles are relieved in almost any part of the island, although there is even here a choice, as cases with scanty expectoration are most benefited in those districts where the atmosphere is most laden with moisture, while those in which there is free or even profuse secretion are more quickly relieved in the neighborhood of Kingston and other parts where the humidity of the air is at a minimum. Patients with nervous prostration receive more benefit from a stay near the seashore than they do in the uplands, and the same is in a measure true of dyspeptics, especially of those in whom the gastric trouble is partly nervous in its origin. Sufferers from Bright's disease do well, as a rule, in all parts of the island, except possibly in the most elevated regions, where in the winter months the thermometer is apt to fall a little too low after the sun goes down, and where, especially on the northern slope, there is at times rather too much rain to be agreeable. The same remarks apply also in the case of rheumatic patients, but the latter would do well to take a course of the waters at one of the numerous mineral springs, of which a few words may be said in closing this article.

There are several medicinal springs in Jamaica, some thermal and others cold, which possess therapeutic properties of no little value, and which are deserving of more careful study by balneologists than they have hitherto received. The most important of these, or at least the best known and the only ones at which passable accommodations for visitors are as yet provided, are the Bath of St. Thomas the Apostle, about a mile from the town of Bath, in the Parish of St. Thomas, the Jamaica Spa, at Silver Hill, in St. Andrew's Parish, and the Milk River Bath at Vere, in the Parish of Clarendon. The first of these is a thermal sulphur, the second a chalybeate, and the third a thermal saline water. All of these springs are quite easily accessible from Kingston.

The limits of this article will not permit of a detailed description of each of these springs. The waters of one or the other of them are of value, taken internally and applied in the form of baths, in the treatment of gout, rheumatism, chronic bronchitis, catarrhal conditions of the stomach and intestines, constipation from abdominal plethora, hepatic and other congestions of the abdominal viscera, amenorrhœa, anæmia and chlorosis, various forms of skin diseases, tertiary syphilitic lesions, and chronic malarial affections. The Government has made grants from time to time for the improvement and care of the buildings at these baths, but there is yet much to be desired in the matter of cuisine, bathing facilities, attendance, and other things that contribute to the comfort and entertainment of the invalid. In the absence of these desiderata they still possess the great advantage that they may be visited in the winter season, when the more pretentious and better equipped spas in Europe and the United States are closed.

There are several lines of steamers running between Jamaica and New York, Boston, Philadelphia, Baltimore, Newport News, and Halifax, the voyage from New York being made in from four to six days. The steamers of the United Fruit Company running from Boston and Philadelphia have excellent accommodations, and service for about forty-five passengers each.

There is usually no lack of amusements in Kingston in the way of horse races, yachting, tennis and cricket matches, etc., and there is also a theatre where performances and concerts are given occasionally during the winter. The roads throughout the island are up to the best English standard and the facilities for riding and driving are unsurpassed. A railroad runs from Kingston in a northwesterly direction to Montego Bay, with a branch line to Anatto Bay and Port Antonio, towns on the north shore, and a spur to Ewarton. Communication with the coast towns is had also by steamers which sail around the island once a week, leaving Kingston every Tuesday. There is frequent mail communication with the United States and Canada, and the island is also connected with this country by cable. Churches of all the leading denominations are found nearly everywhere, and in most of the larger towns are well-appointed clubs, libraries, and social organizations of various sorts.

The best months in which to visit Jamaica are November to April inclusive, as these are the coolest and dryest of the year, but one accustomed to the fierce summer heats of our Northern cities would find a grateful change in the hills of Jamaica even in midsummer.

Much valuable information concerning Jamaica as a health resort may be obtained from a work on "The Climate of Jamaica," by the Hon. J. C. Phillippo, M.D., published by T. & A. Churchill, London, from "The Handbook of Jamaica," published annually in London and Kingston, and from various good guide books recently published.

Jamaica is one of the most beautiful islands of the West Indies both as to the variety and charm of its scenery and the luxuriance of its vegetation; oranges, coffee, the cocoanut, bananas, sugar-cane, and a variety of other tropical fruits grow luxuriantly here. The cultivation and exportation of bananas is now a great industry. The roads, as has been noted above, are hard and white and kept in good repair by the Government, so that one can traverse the island comfortably either by carriage or by bicycle. Whether one skirts the shore with its irregular windings, or seeks the mountainous region of the interior, he will meet not only with a greater variety of climate than is found in any other of the West India islands, but

an infinite variety of attractive scenery. The excellence of the steamers of the United Fruit Company and their swiftness have made an excursion to this island very popular during the winter and spring months. The usual passage from Boston occupies from four to four and a half days. *Thomas Lathrop Stedman.*
Revised by *Edward O. Otis.*

JAMBUL.—This is the local name applied to the bark and seeds of *Eugenia Jambolana* Lamarck, a tree belonging to the natural order Myrtaceæ. It is indigenous to tropical Asia and the neighboring islands, where it grows to a large size and bears a crop of edible fruit in July and August. It is also known as rose apple and Java plum. The *Eugenia pimenta*, the common allspice tree, and *Eugenia caryophyllata*, from which cloves are obtained, are both closely allied species. The fruit varies in size from a cherry to a pigeon's egg, and when ripe is olive-shaped, smooth, juicy, and purplish-black in color. It contains a single seed, which is enclosed in a thin, papery shell. All parts of the tree are astringent, and the bark furnishes a beautiful brown dye. The bark is smooth and whitish, and the cell structure contains a number of characteristic pitted cells which are visible to the naked eye. A white crystalline substance has been obtained, termed jamborine, which is tasteless, insoluble in cold water, soluble in alcohol, ether, and chloroform. It is said to possess the active properties of the seeds, but its composition and properties are uncertain. The seeds are cylindrical in shape, about one-third of an inch in length, hard and dry, and almost tasteless. The following analysis of the seeds has been furnished by Mr. Thomas Christie, of London: Essential oil, a trace; chlorophyll and fat, 0.27; resin soluble in alcohol and ether, 0.30; gallic acid, 1.65; albumin, 1.25; coloring matter, 2.70; moisture, 10.0; insoluble residue, 83.73.

The plant is highly esteemed in India for its medicinal properties, and is used by the native physicians in the treatment of many diseases. The sap or juice expressed from the leaves and bark contains the astringent properties of the plant, and when mixed with goat's milk is thought to be particularly beneficent in the intestinal disorders of children. The juice, and an infusion of the bark, are also employed in dysentery and diarrhœa, and in leucorrhœa. A liquor, jambava, is prepared from the fruit by fermentation; it possesses a stimulating and tonic action, and is a favorite beverage of the Hindoos. The most important use of jambul is as a remedy for diabetes, and it is in the treatment of this disease that it has acquired notoriety and attracted the attention of the profession during the past few years. It has long been employed for this purpose in the East, where it has the reputation of producing a rapid and, in many instances, a permanent cure. The quantity of sugar and urine is reduced, the many distressing symptoms are relieved, and a return of health and strength is said to follow its administration. This treatment was brought to the notice of the English physicians in 1883, by Banatvala, a medical officer in the service of the Madras government, and has been the subject of numerous clinical and experimental researches.

Von Mehring and Graser[1] performed an important series of experiments to demonstrate its power to check the production and lessen excretion of sugar. They produced artificial diabetes in animals by the administration of phloridzin, and carefully estimated the amount of sugar excreted when phloridzin was given alone, and when it was given in combination with jambul. The diminution was found to be invariable and very decided. The following figures indicate the results in three experiments:

Sugar excreted without jambul	12.2	10	10
Sugar excreted with jambul	2.1	1	1.5

They also proved that it was devoid of any toxic action, as very large quantities were given without producing any ill effects.

Experiments have also been made to show its inhibitory action on saccharine fermentation by adding it to a solution of starch and malt, and it has been clearly shown that the quantity of sugar is reduced in accordance with the amount of jambul present. In one instance it was found that a solution of rice starch with a definite proportion of malt produced 27.4 parts of sugar; when fifteen grains of jambul were added the amount was reduced to 9.4 parts, and when twenty-five grains were used only 1.3 parts of sugar were formed.

Following the introduction of the drug there appeared a number of reports of cases treated, and in nearly all it was found that the desired effect was produced in a greater or less degree. Among these are reports by such observers as Kingsbury,[2] Saundby,[3] E. H. Fenwick,[4] Mahomed,[5] Egasse,[6] Villy,[7] Lewaschew,[8] Lawrence,[9] and Britto.[10] In some of the cases in which it was used it failed altogether, in others the sugar reappeared immediately the remedy was discontinued, and frequently it would only lessen the symptoms in a slight degree; but the general tenor of the reports is in favor of the remedy. Notwithstanding the favorable reports it has not come into general use, although occasional reports of its successful employment still appear.

The seeds and the bark both possess the antidiabetic action, but the seeds are the more active of the two. A paper presented by Dr. T. Stevenson, of Bombay, to the Pharmaceutical Conference, held at Edinburgh, 1892, states that the fresh seeds, or an extract prepared from the fresh seeds, is the most serviceable and the only certain method of securing the medicinal properties. Under any circumstances, it is recommended that the seeds should be carefully preserved and reduced to powder only as required. Some such variation in the active properties of the drug may account for the uncertainty of its action and the difference in the quantity administered. The usually recommended dose is five to ten grains of the powder, or five to ten minims of the extract, three or four times a day. This, however, appears to be inadequate, and much larger doses are now advised. Dr. Britto, who reports from India his successful treatment of a number of cases, gave it in doses of one drachm of the powder, or one fluidrachm of the extract, three times a day; and Professor Lewaschew, who reports his experience of two years, in which he employed the drug with marked success, advocates it in doses of as much as from 20 to 40 gm. (ʒ v.–x.) in the twenty-four hours. No toxic action follows its use, but instances of nausea and depression have been reported from its continued use.

Beaumont Small.

[1] The Lancet, p. 902, 1889.
[2] British Medical Journal, March, 1887.
[3] The Lancet, October, 1887.
[4] *Ibid.*, October, 1888.
[5] London Practitioner, December, 1888.
[6] Bulletin Général de Thérapeutie, July, 1890.
[7] *Ibid.*, January, 1891.
[8] British Medical Journal, March, 1891.
[9] The Medical News, January, 1893.
[10] The Therapeutic Gazette, February, 1893.

JASMINE, YELLOW. **SEE GELSEMIUM.**

JAUNDICE.—(*Icterus; Morbus regius; Gelbsucht; Ictère*). Jaundice is a syndrome and not a disease, a condition marked by staining of the skin, conjunctivæ, and urine by bile pigment. Since the first formulation of theories by Frerichs and Kuehne, there has been interminable discussion of what may be termed the pathological physiology of jaundice. The liver was long regarded as a separator rather than a producer of bile pigment; given a cause of blood destruction, bilirubin could be formed in the blood stream or in tissues; the hepatic cell might prove unequal to the demands of elimination or its function be suppressed and jaundice resulted. Of late years there has been unity in abandoning such a view, and the paramount importance of the liver cell in the manufacture of bile pigments has been unquestioned. The idea of hæmatogenous jaundice has become obsolete and all

jaundice is regarded as of liver origin. It is true that small amounts of bilirubin may be found in other places than in the liver; bile pigment has been found in apoplectic foci, blood extravasations, and hemorrhagic infarcts in the form of hæmatoidin crystals which are identical with bilirubin. Loewit, in frogs, showed that leucocytes could take up fragments of red cells and elaborate them in different tissues to granules of bile pigment. Naunyn and Minkowski, in the course of their experiments with hæmolytic poisons in geese, demonstrated leucocytes in the liver containing fragments of red corpuscles and granules of bile pigment. Within a few months Croftan, in the course of his experiments on the bile acids, has emphasized anew the extrahepatic origin of bilirubin and of bile acids. Clinically the facts are of no import. The experiments of Kunde and Moleschott with cold-blooded animals, of Stern with pigeons, of Naunyn and Minkowski with geese, have shown conclusively that it is the liver cell above all that is concerned in the elaboration of bilirubin from hæmoglobin.

Practically every icterus is an icterus from absorption of bile from the liver. Without liver function there is no icterus. The mechanism of absorption is plain in the jaundice termed obstructive or mechanical, the jaundice of stasis, "ascending jaundice"; stasis in the ducts overcomes the pressure of the bile secretion (not more than 200 mm. of water), bile is secreted at higher pressure and passes from the intercellular duct to the lymphatic vessels near the bile capillaries, thence to the larger lymphatics, thoracic duct, and to the blood stream. The liver cells are continuous with the walls of the bile capillaries, and Kuppfer has demonstrated prolongations of the capillaries even within the liver cell. It is possible under certain conditions that functionally disordered liver cells may send bile to the blood capillaries and not to the bile ducts, or may allow passage of bile from the ducts back to the blood-vessels and not to the lymphatics. This is the so-called parapedesis of bile (Minkowski), diffusion icterus (Liebermeister), paracholia (E. Pick).

The investigations of Charcot, Legg, and others have broadened our views of mechanical jaundice. Under the influence of increased hæmolysis from toxic or infectious cause, excess of hæmoglobin is brought to the liver and elaborated into bile. There is increase in quantity of bile, but particularly an increase in viscidity and pigments, a polycholia and particularly a pleiochromia. This thick, viscid bile leads to stasis in the small bile channels, to irritation and swelling of the mucosa, to obstruction and to icterus by absorption; again an icterus of obstruction, but a descending rather than an ascending icterus. Even without increased amount of viscidity of bile, the eliminated poisons in course of an intoxication or infection may lead to catarrh of the bile terminals, to swelling with mechanical blocking and absorption. Though all cases of jaundice may be classed as obstructive, the classification of Hunter is a convenient one for descriptive purposes.

I. Obstructive Jaundice.—Causes acting from within or without the bile ducts. The obstruction is obviously mechanical and independent of changes in the blood or bile. The following is substantially the table of Murchison:

A. Obstruction by Foreign Bodies within the Duct.
1. Gall stones, inspissated bile, blood clot.
2. Foreign bodies from the intestines.
3. Parasites—hydatids, distomata, lumbricoids.

B. Obstruction by Catarrhal Swelling of Large or Small Ducts.

C. Obstruction by Stricture or Obliteration of Ducts.
1. Congenital deficiency or stricture of ducts.
2. Stricture from perihepatitis, from ulcer of the duodenum, from ulcers or scars in the bile ducts.
3. Spasmodic stricture (icterus psychicus).

D. Obstruction by Tumors at the Papilla or of the Bile Ducts.

Fibroma, lipoma, gumma, papilloma, xanthoma, sarcoma, carcinoma.

E. Obstruction by Pressure from without.

(1) Tumors of the liver; (2) tumors of the gall bladder; (3) enlarged glands in the fissure of the liver; (4) tumors of the stomach or duodenum; (5) tumors of the pancreas; (6) tumors of the kidney; (7) floating kidney; (8) omental tumors; (9) retroperitoneal tumors; (10) aneurisms of abdominal aorta, hepatic artery; (11) fæcal tumors, especially of the hepatic flexure; (12) pregnant uterus, tumors of the uterus; (13) ovarian tumors.

II. Toxæmic Jaundice.—Jaundice dependent on changes in the blood and bile; the end cause is obstruction dependent on increased viscidity of bile or on catarrhal swelling of the bile ducts. This is the group formerly called hæmatogenous. Hunter classifies causes as follows:

1. *Definite Poisons.*—Phosphorus, arsenic, toluylendiamin, snake venom.

2. *Poisons of Infectious Fevers.*—Yellow fever, malaria, pyæmia, typhus, typhoid, relapsing fever, scarlatina, pneumonia.

3. *Special Icterogenic Poisons.*—These are of probable infective nature. Various names have been given to the jaundice, as epidemic, infectious, febrile, malignant, septic, Weil's disease, icterus typhosus, icterus gravis, acute yellow atrophy of the liver.

Symptoms. I. *Obstructive Jundice.*—1. Staining of the tissues is most striking and is due to bilirubin. Connective tissue has particular affinity for the pigment. The conjunctivæ usually show the earliest tinge; the color is well seen in the mucous membrane of the hard palate, especially on pressure; color of the skin varies from sulphur, lemon, or saffron hue in slight cases to greenish, bronze, or even greenish-black in chronic cases with complete obstruction. The pigmentation is most marked over the forehead, temples, scalp, upper extremities, and thorax. The pigment lies in granular masses in the deepest layers of the rete Malpighii, and may persist ten or twenty days after it has disappeared from the blood. The cornea, peripheral nerves, cartilage, hair, and teeth escape stain; the brain is not colored, except in the newborn; the fœtus may be lightly jaundiced. 2. Nearly all secretions show presence of bilirubin. It can be demonstrated in the urine, sweat, exudates, amniotic fluid, and pus; it is inconstant in the milk, rarely present in the sputum except in pneumonia, has been demonstrated exceptionally in saliva, but is not found in the tears. The urine is usually dark yellow or brown, sometimes reddish or greenish. The foam is yellow, immersed filter paper is stained yellow, and the presence of bilirubin can be shown by a number of tests. In the Smith-Rosin test, 3 c.c. of a solution of tincture of iodine diluted ten times with alcohol is added to 10 c.c. of urine; a green ring forms at the zone of contact. Gmelin's test: Fuming nitric acid is poured beneath a layer of urine in a conical glass; a play of colors occurs at the zone of contact—yellow, green, blue, violet, to red; the green color is most characteristic. The Schwerdtfeger-Huppert and Gluzinski tests are equally delicate but less convenient. If the serum contains only slight quantities of bile pigments, the urine may contain only urobilin and no bilirubin. The urine is yellowish-red and only rarely brownish-red. Urobilin occurs in small quantity in normal urine, occurs in the fæces as stercobilin, may occur alone in the urine in slight jaundice, at the beginning or end of severe jaundice, usually disappears from the urine when bile is totally shut off from the intestine. It is a reduction product of bilirubin or hæmoglobin; and reduction may occur either in the intestine or in the tissues. There is no true urobilin icterus; the staining of the skin is always by bilirubin. To test for urobilin, water is poured carefully over the urine in a test tube; urobilin diffuses more rapidly than bilirubin, and may be recognized with the spectroscope (Hayem). The following table of Quincke, little modified from that of Hayem and Tissier, shows the shifting relations of the bile pigments in urine, fæces, and skin in the course of ordinary obstructive jaundice:

Skin.	Serum.	Urine.	Fæces.
1. Very slight yellow	Bilirubin 0	Bilirubin 0....... Urobilin 0 or little	Normal color.
2. Light yellow.....	Bilirubin +	Bilirubin − ...... Urobilin +.......	Colored.
3. Yellow..........	Bilirubin +	Bilirubin +...... Urobilin +.......	Pale.
4. Deeply yellow...	Bilirubin +	Bilirubin +...... Urobilin + or 0..	Clay color.

Besides bilirubin and urobilin the urine contains bile acids and at times nucleo-albumin and albumin. Bile-stained cells and hyaline and finely granular casts are found in all jaundice urines.

3. Pruritus is frequent, and in marked jaundice may be severe and tormenting. It is an intoxication symptom, and largely modified by individual peculiarity; it may precede the jaundice, and in fact be present for long periods without jaundice, as in hepatic cirrhosis; but as a rule it is not intense save in complete and long-standing obstruction. It may cease when bile reappears in the stools, though the skin still remains colored. Urticaria, eczema, fissures, and boils occur as a result of scratching. Xanthoma, xanthelasma, or vitiligoidea is a peculiar condition characterized by formation of yellowish flat patches or tubercles; the flat variety occurs on the eyelids, the tubercular form elsewhere on the skin or in the viscera. The association with icterus is not a necessary one. Sweating is frequent and may be confined to the back or abdomen. Telangiectases may develop in chronic cases in the skin and occasionally in the mucous membrane of the tongue and lips. Clubbing of the nails has been occasionally observed, and periosteal nodes may form.

4. The color of the fæces may be modified. In total obstruction the stools may be pasty and more or less grayish-white or clay-colored. The color is due partly to absence of modified bile pigment, and partly to the large amount of undigested fat; according to F. Mueller, from fifty-five to seventy-eight per cent. of fat goes to waste when bile is wholly shut off from the intestines, instead of normally from seven to ten per cent. With partial obstruction the stools are more colored; return of color may be the first sign of relief from total obstruction. Formerly much stress was laid on the antiseptic properties of bile, but we now know that the bile has little influence on bacterial growth and controls but little the odor of the fæces.

5. Slow pulse is a common symptom, especially of catarrhal jaundice. There may be 60, 50, or even as low as 30 or 20 beats a minute. The phenomenon is variously attributed to action of bile acids on the vagus, heart muscle, or intracardial ganglia; irritation of the vagus is the most probable cause, for Wintrend has demonstrated a rise from 40 to 120 after atropine injection. Later, in a chronic jaundice, an originally slow pulse may rise to normal or increased rate.

6. Disturbances of vision are rare—xanthopsia, hemeralopia, nyctalopia.

7. Digestive disorders are common but equivocal. The usual complaints are of anorexia, bitter taste in the mouth, distaste for meats or fats, flatulence, constipation, or occasional diarrhœa.

8. Nervous symptoms are of many kinds. Physical and psychical weakness, depression, irritability are present in mild cases; with persistent jaundice severe disturbances may occur. The general condition grows worse, a typhoid state develops, dulness and stupor deepen into coma that proves fatal, coma alternates with states of excitement and delirium, or general convulsions of indefinite nature end the scene. The symptoms directly suggest intoxication, and the condition has long borne the name of cholæmia. The name is not a good one, as the same group of symptoms may terminate a cirrhosis of which jaundice forms no part. It is an auto-intoxication of complex kind, as shown by the variety and inconstancy of the symptoms. The term hepatic intoxication, proposed by Quincke, should supersede cholæmia.

9. Hemorrhage. The presence of bile constituents slows coagulation of the blood, and in long-continued icterus, instead of the normal time of three and a half to four minutes, coagulation may be delayed to eleven or twelve minutes (Osler). The tendency to bleeding is shown in spontaneous hemorrhages—purpura, suggillations, more rarely bleeding from mucous membranes, or by profuse and fatal hemorrhage after operations. It is well known that surgeons operate with dread in cases of long-standing jaundice.

II. *Toxæmic Jaundice.*—In this form obstruction depends upon increased viscidity of bile, due to blood changes or to catarrh of small bile ducts; no obvious obstruction is to be found in large ducts. Bile is never absent from the fæces; in fact, the stools may be very dark from excess of bile (polycholia). The bile acids are not constant in the urine, but this is of no clinical importance. Coloring of the skin is usually less deep, constitutional disturbances are as a rule decidedly more marked; the jaundice seems often merely a symptom of a general infection. All the cases of this group present about the same clinical picture; differences in the symptoms and course are due to the variety and especially to the intensity of the intoxication. There may be gradations from an apparently simple epidemic catarrhal jaundice to the syndrome of malignant jaundice or Weil's disease, or to the severest type of icterus gravis or acute yellow atrophy. For further discussion of this group, see articles on *Phosphorus Poisoning*, *Weil's Disease*, *Yellow Fever*, *Liver Diseases: Acute Yellow Atrophy*.

Morbid Anatomy and Course.—The pathological findings of icterus vary widely with the causes; they are sufficiently discussed in connection with symptomatology or in the sections dealing with the special diseases. The course and prognosis vary also with the cause; in general, prognosis is less good when obstructive jaundice has lasted three or four months; after eight to twelve months liability to hemorrhage or to sudden severe nervous symptoms renders the outlook unfavorable. Budd, however, cites recovery after four years; Murchison, Barth, and Bismer report a favorable termination after six years' duration; Legendre, Gailliard, and Debove mention cases of complete obstruction of twelve, twenty, twenty-five years' standing without much general disturbance!

Varieties of Jaundice.—1. *Icterus Neonatorum.*—Jaundice of the newborn may be (*a*) severe, due to congenital stricture or absence of the bile ducts, to syphilis, or to sepsis; this form rapidly proves fatal; (*b*) mild or physiological. This occurs in one-third or two-thirds of all infants born in hospital, and in a somewhat smaller per cent. of private cases. It is more frequent in boys, in premature infants, in cases in which chloroform was used, or in cases attended with marked congestion. The jaundice appears on the second or third day, is most marked in the face and upper part of the body, as a rule is not deep, the conjunctivæ are stained only in severe cases, there is little or no general disturbance, the color fades in from a few days to three or four weeks. The urine, as a rule, is of normal yellow color and contains no soluble bile pigment; it frequently shows traces of albumin, and the sediment may show bile-stained kidney epithelium or cells enclosing granules or crystals of bilirubin. Bilirubin is held in the kidney in the form of infarcts. There is no urobilinuria; the fæces are of normal yellow color. Pathogenesis is obscure. The benign character shows the practical physiological nature of the process; it may depend in part on the increased blood destruction and consequent polycholia of the first days after birth, in part on the slow excretion of bile by the kidney (infarct formation), in part on lack of bile reduction in the intestine. More probable is the explanation of Franck and Quincke that the icterus depends on increased bile absorption from the intestines; the meconium contains bilirubin, bile secretion is increased with ingestion of the first food, bile is consequently absorbed in quantity into the portal blood, and in the first few days patency of the ductus venosus Arantii allows the bile constituents to enter in part the

vena cava and so reach the general blood stream without passing the liver.

2. *Icterus after Hemorrhages.*—Definite icterus has been observed after blood extravasations and internal hemorrhages. The staining appears in from three to ten days' after the hemorrhage, is of slight degree, and fades in a few days or weeks. Urobilinuria accompanies and, in fact, precedes the jaundice; it is extremely rare to find bilirubin in the urine. Elaboration of the bile pigment probably does not take place locally; hæmatoidin crystals may form, but this is a slow process and the crystals show little tendency to solution. More probable is the solution of hæmoglobin *in situ* and its transformation into bilirubin in the liver; the jaundice is hepatogenous, an icterus pleiochromicus. With small extravasations no jaundice occurs, only urobilinuria.

3. *Inanition Icterus.*—Slight staining of the conjunctivæ or skin may occur in inanition or starvation. Trendelenburg observed a case with slight bilirubinuria. It is a common event to find bile in the urine of fasting dogs—the absorption occurs within the liver.

4. *Icterus Syphiliticus.*—This is the icterus syphiliticus præcox. It occurs in the secondary stage, is not frequent, occurs oftener in women (Fournier). The cases show generally severe secondary symptoms, eruptions, and marked glandular enlargements (Werner). It is a mechanical jaundice and due to swelling of the glands in the portal fissure (Lancereaux). In one case Quincke observed ascites and splenic tumor coming and going with the jaundice.

5. *Icterus Psychicus, Icterus Spasticus, Icterus Ex emotione.*—In the minds of the laity the emotions play a large part in liver pathology. The only cases of jaundice that can be ascribed to nerve influence are those which occur within a few hours or even minutes after a sudden nerve shock, as fright, anger, fear. There are two classes of such cases: 1. Jaundice coming on immediately after severe shock; in all literature examples of this class are extremely rare; two cases of Villeneuve (1818) are cited by Murchison. 2. Jaundice occurring a few hours after great nerve shock or strain. This is comparatively common; the jaundice is light and of short duration; in a few cases acute yellow atrophy has followed. Various explanations have been advanced—polycholia, lowered portal pressure (Frerichs). The most probable explanation is that of spasmodic contraction of the bile ducts with increased back pressure and quick absorption.

Herbert C. Moffitt.

JAWS, INJURIES AND DISEASES OF. — INJURIES AND DISEASES OF THE UPPER JAW.—The upper jaw is peculiar from the fact of its possessing a large cavity, the antrum of Highmore. This cavity is situated in the body of the bone, and is lined with mucous membrane continuous with that of the nasal cavity through a small orifice opening into the middle meatus.

On account of its structure the upper jaw is more subject to diseases than the lower. The affections of the bone calling for surgical interference are injuries, inflammation and abscess, cystic diseases, and tumors.

FRACTURES OF THE UPPER JAW.—Owing to the position of the upper jaw, protected on all sides by its outlying processes of bone—the malar bone externally and the nasal bones internally—fracture of the upper jaw is not a very frequent accident. Almost invariably fracture of this bone is associated with fracture of the more prominent bones of the face, with which it is articulated. Direct violence, such as blows upon the face, falls from great heights, etc., is usually the cause of the fracture.

The fracture may be of the penetrating variety, consisting of a small opening into the antrum made by a sharp-pointed instrument, which may enter by way of the orbit, the palate, the nostril, or the anterior wall of the cavity. Such wounds, as a general rule, heal rapidly, and require but little attention on the part of the surgeon.

Fracture may involve any part of the bone—the nasal, palatal, or alveolar process, or the body of the bone. As the result of falls upon the face from great heights, the fracture, in a few recorded cases, has been vertical in the median line, constituting a diastasis or separation of the two superior maxillary bones.

Comminuted fractures, attended with the most frightful deformity, as the result of gunshot wounds, are occasionally met with.

When the alveolar process is separated from the body of the bone there is usually marked displacement.

The anterior wall of the antrum of Highmore is sometimes crushed in by fragments of the malar bone driven down upon it by the force of blows.

The soft parts overlying the fracture are nearly always extensively involved. Hemorrhage from wounds of branches of the internal maxillary artery is occasionally very profuse—sometimes even requiring the ligation of the common carotid artery, or the application of the actual cautery to the bleeding point.

When a fracture of the nasal process of the upper jaw is complicated with a fracture of the nasal bones in which the mucous membrane of the nose has been more or less lacerated, extensive emphysema of the face may take place.

If the line of fracture runs through the infra-orbital foramen, causing contusion or laceration of the infra-orbital nerve, temporary paralysis of the parts supplied by that nerve may ensue.

Obstruction of the lachrymal duct, with a constant overflow of tears upon the cheek, may follow fracture of the upper jaw.

Symptoms.—In the majority of cases recognition of fracture of the upper jaw is not difficult. Deep-seated pain, increase of saliva, hemorrhage from the mouth, and the special signs of fracture, viz., crepitus, preternatural mobility, and deformity, are all present in greater or less degree. The accessible position of every part of the bone makes it usually an easy matter to detect a fracture of the upper jaw.

Treatment.—In the treatment of fractures of the upper jaw the indications are to replace, by manipulation, the fragments as accurately as possible, and, by suitable appliances, to render them immovable. Pressing the lower jaw firmly against the upper with a bandage will in most cases suffice.

If the tendency to displacement is great, as in fractures of the alveolus, it may be necessary to wire the teeth of opposing fragments together, or to adjust a gutta-percha or vulcanite interdental splint.

When the fracture is comminuted and compound, great care should be taken to preserve every fragment, however loosely attached, as the experience of a great many surgeons has shown that such fragments reunite very readily. Another point to be observed in the treatment of fractures of the upper jaw is not to extract loosened teeth, as, in addition to the fact that they most frequently become firm again, their extraction is attended with some danger of removing fragments of bone that might have been preserved.

Repair in cases of average severity takes place in from thirty to forty days with a scanty formation of callus, and not infrequently in less time. The vitality of the bone is exceptionally great; hence the rule laid down by Malgaigne and some of his predecessors, and repeated by all subsequent writers, to leave every fragment that is not absolutely and entirely detached. Although this rule is a sound one, it occasionally happens that fragments become necrosed and have to be removed.[6]

INFLAMMATION, either acute or chronic, may attack the mucous membrane of the antrum or the periosteum of the bone. The cause of the inflammation is most commonly irritation set up by carious teeth, though it may originate from mechanical injury, from the poisonous effects of syphilis, scrofula, the exanthematous fevers, mercury, or phosphorus. Its tendency is to run rapidly on to suppuration, and in the majority of cases this process has been already established when the surgeon is called.

When the mucous membrane of the antrum is in-

flamed, the symptoms are by no means clear. Aching of the molar teeth is present, there is more or less puffy, œdematous swelling of the cheek, and occasionally there may be observed a discharge of mucus from the nostril of the affected side.

In periostitis there is always severe pain of a throbbing, tensive character, aggravated at night; swelling of the cheek, often so great as to distort the features, is also present; the teeth are raised in their sockets, and the least pressure upon them gives rise to the sharpest pain.

Treatment.—In order to avert suppuration the treatment should be prompt and active. All decayed teeth should be at once removed as the most probable causes of the mischief. Saline cathartics should be exhibited, and local depletion by means of leeches applied to the gums, or free incisions, together with hot fomentations, should be employed.

Alveolar Abscess, the immediate effect of inflammation at the root of a tooth, may be superficial or deep. When superficial it is commonly known as gumboil, which is recognized as a puffy swelling of the gums, usually small in volume, but often exquisitely tender and painful. This form of abscess, after a brief period, ruptures spontaneously or upon slight pressure with the finger, and recovery speedily ensues.

The deep alveolar abscess, which more directly results from diseased teeth, commences in the substance of the bone. The abscess cavity, at first very small, rapidly increases in size, the alveolar process becoming carious and undergoing absorption. The pus may find an outlet for itself by the side of a tooth, or, if resistance in that direction is too great, the alveolar process may be perforated and the pus burrow beneath the mucous membrane. Occasionally the pus burrows beneath the periosteum of the palate, afterward pointing in the roof of the mouth.

Treatment.—The treatment of alveolar abscess is free incision and extraction of the peccant tooth. This should be done early, as delay may lead to extensive necrosis, or to the formation of a long sinus, most difficult to heal.

Suppuration in the Antrum.—Accumulation of pus within the antrum—erroneously termed abscess, more properly empyema of the antrum—is most frequently caused by irritation set up by diseased fangs of teeth which normally project upward into the cavity and form prominences upon its floor. The teeth most usually involved are the first and second molars, though it may be the bicuspid or canine. Only a thin partition of bone separates the roots of these teeth from the cavity, and not infrequently the root of one or more of these teeth penetrates the cavity and lies in contact with the antral mucous membrane. The disease may also depend upon a catarrhal inflammation of the lining membrane, may follow violent blows upon the face, or arise by extension of inflammation from the nasal cavity, or from suppurative degeneration of cysts of the antrum.

Symptoms.—If very rapid in its formation, the symptoms of suppuration in the antrum are pain in the head and face, aching of the teeth on the affected side, swelling of the face and gums, and the discharge of an offensive pus into the nose when the patient is recumbent or forcibly blows the nose. The constant discharge of fetid pus through the nose often occasions the mistake that the disease is ozæna, but the character of the matter and the fact that the fetor is most perceptible to the patient, are sufficient marks of distinction. Digestion is much disturbed by the constant entrance of pus into the stomach, and the general health of the patient is on that account often very much impaired.

If the suppurative process has been very slow and gradual, the symptoms are hardly sufficient to attract attention until the disease has made considerable progress.

The pus most usually finds an exit for itself through the opening from the antrum into the nose, or into the mouth along the side of diseased teeth. Expansion of the bone rarely occurs, except when no outlet for the escape of pus is afforded. When there exists no means of escape for the pus and it accumulates in the cavity, the bone becomes expanded, the cheek is pushed forward, and the walls of the antrum become so thinned by absorption that when pressed upon a peculiar crackling sensation is felt. The bone may be expanded upon any or all of its surfaces, orbital, buccal, palatal, or nasal. In several recorded cases the pressure upward has caused protrusion of the eyeball with permanent amaurosis. Obstruction of the lachrymal duct by the expansion of the bone frequently brings about a constant overflow of tears upon the cheek.

Treatment.—The treatment of suppuration in the antrum consists in providing a free opening for the pus to escape before extensive destruction of the walls of the cavity has taken place. This may be effected by the extraction of a tooth on the affected side, preferably the first molar, and enlarging the opening through the socket by means of a trocar or drill. In edentulous jaws, attempts to penetrate into the antrum through the alveolus should never be made, as under these circumstances the bone is greatly thickened and consolidated. The most effectual method of evacuating the pus is to make the opening above the alveolar process by means of a drill, a carpenter's gimlet, or an ordinary trocar, care being taken that the instrument is not driven upward with such force as to pierce the orbital plate.

If the opening has been made through the socket of a tooth, the passage should be kept closed with a plug of cotton, or a gutta-percha or metallic plate adjusted over the teeth to prevent the entrance of food into the cavity.

The cavity should be frequently syringed out through the opening with an antiseptic solution—corrosive sublimate, 1 : 2,000, or carbolic acid, 1 : 30.

The most assiduous attention is necessary to bring about a perfect cure, and often months elapse before the disease may be said to be at an end.

Cystic Disease of the Antrum.—In this disease the antrum becomes distended by a dark-colored, glairy, and in some instances gelatinous fluid, which frequently contains cholesterin in considerable quantity. The old name applied to the disease was *hydrops antri*, or dropsy of the antrum, and it was supposed to depend upon the retention of the natural secretion of the mucous membrane lining the sinus, the escape of which had been prevented by the closure of the opening between the antrum and the nose; but modern research has shown that such a view was not correct. The cysts most likely depend upon cystic degeneration of the glandular follicles thickly aggregated over the mucous membrane lining the cavity.

Fig. 2977.—Cystic Tumor of Antrum. (Erichsen.)

Symptoms.—The disease is of painless growth and the expansion of the bone gradual. In course of time it leads to marked deformity—the cheek becomes prominent and round; the eye protrudes from the orbit; the nose is pushed to the opposite side; the nostril becomes occluded; and the palate is depressed, often to such an extent as seriously to embarrass deglutition. The enlargement presents itself as a rounded tumor, soft and elastic at some portions of its surface, hard and resisting at others. Pressure upon the swelling often elicits the peculiar egg-shell crackling characteristic of those conditions in which the bone is greatly expanded and thinned. The general appearance of the disease closely resembles that of solid tumors of the upper jaw, which fact has caused surgeons, in a number of instances, to excise the entire upper jaw unnecessarily. In all doubtful cases of swelling of the upper jaw, therefore, ex-

ploratory punctures should be made before resort is had to the more serious operation of excision.

Treatment.—Acting upon the false belief that the enlargement consisted of the pent-up secretion of the antral mucous membrane, surgeons formerly attempted to re-establish the normal opening between the sinus and the nose, but naturally such a procedure never met with success.

The proper treatment consists of the evacuation of the contents of the cyst by means of free incisions, and the establishment of efficient drainage until the tendency to recurrence no longer exists. This may be easily accomplished by incising the most prominent part of the tumor, usually beneath the cheek, evacuating the contents through the opening, and dilating the passage thoroughly with the finger. If the cyst is large, a portion of the bone or of the cyst wall should be cut away. The cavity should be thoroughly washed out, several times daily, with some stimulating or antiseptic solution until all discharge ceases. The deformity occasioned by the distention of the bone will eventually entirely disappear.

Polypus of the Antrum.—This form of morbid growth in the antrum is rare. Like polypus of the nasal cavity, to which it is similar in pathology, it takes its origin from the mucous membrane, and may be either fibrous or gelatinous, most frequently the latter.

When small its presence is unsuspected, and it is only after it has attained considerable volume and has, by its size, led to absorption of the thin internal wall of the antrum, and protruded into the nostril, that the real nature of the disease is manifested.

Until this form of growth reaches large dimensions, surgical interference is rarely called for. Thorough removal, by opening up the anterior wall of the antrum, or through the nose if possible, is the proper method of treatment.

Dentigerous Cysts develop in the jaw in consequence of some error in the growth and eruption of a tooth, most frequently a permanent one, though Heath mentions a case in which the tooth involved was of the temporary set. Tomes believes that dentigerous cysts are the result of the gradual increase of the small amount of fluid left in the tooth sac after development of the enamel. This form of cysts most frequently occurs in young adults. In the upper jaw they nearly always occupy the antrum.

In general appearance dentigerous cysts strongly resemble simple cysts, described above. They cause a slow, painless enlargment of the jaw, which, after it has reached a considerable size, crackles upon pressure, though this symptom is not constant, on account of the thick and highly organized wall of the cyst.

Treatment.—The treatment of dentigerous cysts is the same as that of simple cysts, namely, free incision and evacuation of their contents. The contained tooth, which is usually found embedded in or lying loose upon the cyst wall, should be removed, and a portion of the sac cut away. The operation should, if possible, be performed from within the mouth. Entire recovery, without deformity, usually follows the operation.

Solid Tumors of the Upper Jaw—Fibromata.—Fibrous tumors of the upper jaw may be either endosteal or periosteal in origin, and may occupy the antrum of Highmore or grow from the alveolar process, the latter variety being known as fibrous epulis.

In structure, fibromata are similar to fibrous tumors of other parts of the body, and are liable to the same kinds of degenerative changes.

The upper jaw is not so often the seat of fibrous tumors as the lower.

Frequently these growths contain spicula of bone or nodules of cartilage, either of which may be present in large quantity.

Inflammation resulting from the irritation of decayed teeth or mechanical injury may be the starting-point of the disease. More frequently, however, the cause is not apparent.

Though usually of slow growth, fibromata occasionally reach enormous dimensions. When originating within the antrum, a fibroma may extend in every direction. The bony walls of the cavity give way before it and undergo absorption. Processes of the growth may extend into the mouth, the nasal cavity, and the orbit, and distend the cheeks, giving rise to the most hideous deformity. The health of a patient who is the subject of fibroma of the upper jaw usually remains unimpaired.

Fibrous Epulis is a small, firm tumor of fibrous structure, which grows from the periosteum of the alveolar process close to the junction of the gum with the teeth, or even between the teeth. It grows slowly and painlessly, and seldom reaches a large size, though a few cases have been reported in which such outgrowths have attained sufficient volume to cause considerable deformity. As the tumor increases in size the adjacent teeth become loosened, and eventually drop out. It bleeds when manipulated, and is not infrequently ulcerated on account of the pressure of the teeth of the lower jaw. As in fibromata of the body of the jaw, epulis frequently contains bony spicula, which radiate into its substance from the attachment of the tumor to the jaw.

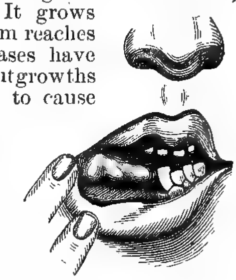


Fig. 2978.—Epulis of Lower Jaw. (Erichsen.)

Fibromata may be distinguished from malignant tumors of the upper jaw by their slowness of growth, their hard and resisting consistence, the absence of pain, their independent growth, and the immunity of the lymphatic glands.

Treatment.—When the tumor is located within the antrum and is of moderate size, it may be possible to enucleate it from within the mouth without disfigurement of the face. This may be accomplished by dissecting the cheek from the bone and entering into the antrum through its anterior wall.

If the growth is large, and has in a measure substituted itself for the upper jaw, nothing less than complete excision of the bone will suffice. In the treatment of epulis thorough removal of the growth, with a portion of the bone from which it sprang, should be done to insure against a return of the disease.

Enchondromata.—Pure cartilaginous tumors of the upper jaw are extremely rare. They may grow from the surface of the bone or from within the antrum. They usually appear early in life, and grow more rapidly than fibrous tumors. Enchondromata may reach immense size, as in the case reported by O'Shaughnessy, who removed a tumor of this kind, together with the upper jaw, which weighed four pounds.

In general appearance and in progress the enchondroma differs so little from the fibroma that during life it is impossible to differentiate between them. Ossification of the growth is a very frequent occurrence, and it is not unlikely that nearly all osseous tumors were originally cartilaginous. The tendency to recur is much greater than it is in the case of fibrous tumors, and for this reason extirpation of enchondromata should be most thorough. Eight operations for the removal of enchondroma of the upper jaw were performed upon a patient whose case has been reported by Fergusson. It is not unlikely that the disposition of enchondromata to recur has been greatly exaggerated, as, no doubt, in many cases sarcomatous tumors which have undergone chondrification have been regarded as originally cartilaginous.

Treatment.—The treatment of enchondromata should be the same as applies to fibromata, except that the surgeon should be even more careful to go wide of the disease, in order to guard against recurrence.

Osteomata are more frequently met with in the lower than in the upper jaw. This form of tumor in its structure possesses all the characteristics of true bone. It may be cancellous in structure, enclosed in a thin casing

of compact bone, or of denser consistence, hard and compact throughout like ivory.

Hyperostosis is a disease of the jaw which consists of a diffused hypertrophy of the bone, with frequently total obliteration of the antrum. Partial hyperostosis may take place in the alveolar process as the result of irritation proceeding from a misplaced or diseased tooth.

Osteomata of the upper jaw have been known to become loose in their attachments, and finally to become spontaneously detached.

It is not an easy matter to distinguish an osteoma from an enchondroma, or even from a fibroma, but its slow growth, extreme hardness, and irregular, nodulated, or tuberous surface will be of service in making a diagnosis.

Treatment.—Osseous tumors of the upper jaw should be removed with the part of the bone from which they grow, or if large and the source of great deformity, the entire jaw should be excised.

SARCOMATA of the upper jaw are tumors of connective-tissue origin, made up chiefly of embryonic cells. They are met with most frequently in early and middle life. Sarcomata are essentially malignant in nature, being almost certain to recur after removal, and in their growth infiltrating the neighboring tissues. The sarcomata are very vascular and grow rapidly, often reaching immense volume. They are conveniently divided into three classes, according to the kind of cells that enter into their composition—namely, the spindle-celled, the round-celled, and myeloid or giant-celled.

The spindle-celled sarcoma is most frequently found in the antrum. It is made up of spindle-shaped cells of varying size, closely packed in a homogeneous basis substance, held together by a scanty fibrous tissue. It closely resembles the fibroma in general appearance.

The round-celled sarcoma, as its name implies, is composed principally of large, round cells, very greatly resembling leucocytes. Both spindle-shaped and round cells are occasionally found in the same tumor. Both varieties frequently undergo osseous or cartilaginous transformation, often to such an extent as to mask the real nature of the neoplasm. When the tumor occupies the antrum it pursues the same course as other solid tumors of that cavity, causing enlargement of the bone, bulging of the cheek, etc., but differs from them in that it grows more rapidly, is more prone to ulcerate, is very vascular, is of soft consistence in the majority of cases, and the lymphatic glands frequently become secondarily affected.

The myeloid sarcoma occurs at an early age, and in most cases grows from the alveolar process, where it is known as myeloid epulis. In structure it is composed of large polynucleated cells. This form of sarcoma grows rapidly, is extremely vascular, and is soft and elastic to the touch.

Treatment.—No matter how thoroughly sarcomata of the upper jaw are removed, their malignancy is manifested by the fact that in the majority of cases they recur. Occasionally they have been removed, together with a large portion of the bone from which they grew, with perfect success; and in exceptional cases, when the growth is small and in a measure isolated, it may be expedient to excise it with a portion of the bone; but when the nature of the tumor is clearly apparent, and when it has reached a large size, nothing short of complete excision of the entire upper jaw will be of any avail.

EPITHELIOMA is the only form of carcinomatous growth connected with the jaws.

There are two distinct varieties of epithelioma of the upper jaw: the squamous, which grows from the gums, or from the mucous membrane of the palate, and the columnar, which always commences in the nasal cavity or the antrum. Epithelioma is rarely met with before the age of forty.

The squamous epithelioma usually commences as a small ragged ulcer of the gum or the palate. As the ulcerative process extends, the bone gives way before it, and the antrum is invaded. This cavity soon becomes filled with the epitheliomatous deposit, and the surrounding tissues are rapidly infiltrated. The antrum becoming overdistended with the mass, the external walls yield, the cheek bulges, the nostril is occluded, the orbital plate is encroached upon, and the eye protrudes. The skin over the tumor is stretched, and eventually becomes livid. Later on, the skin gives way and an irregular ulcer is formed, through which protrudes a fungous mass, from the surface of which a fetid, thin, muco-purulent fluid is constantly discharged. Profuse hemorrhages are not infrequent.

The lymphatic glands beneath the jaw, behind the ear, and at the temple become involved in the advanced stages of the disease.

The progress of the disease is variable, being sometimes very rapid, at other times slow.

The columnar epithelioma grows either from the mucous membrane of the palate or from that of the antrum. It is invariably of rapid growth. It is usually softer than the squamous variety. When growing from the antrum, it pursues the same course and presents the same symptoms as squamous epithelioma.

When the tumor occupies the nostril, it is liable to be mistaken for nasal polypus.

Treatment.—When epithelioma attacks the upper jaw, complete excision of the bone should be the rule, and the earlier in the course of the disease it is done the greater the chance of preventing its return or the longer the immunity from recurrence.

Thorough eradication of the disease should be the object of the surgeon. Even when there can be no hope of removing all the disease, an operation is nearly always advisable, as it may prolong life and render the patient more comfortable.

OPERATIONS UPON THE UPPER JAW.—The nature of the operation is determined by the character and extent of the morbid growth. If the tumor is innocent, care should be taken to disfigure the face as little as possible, and to sacrifice no more of the bone than is absolutely necessary.

Very often, when the tumor is small and confined to a limited portion of the bone, it may be removed from within the mouth after dissecting up the cheek from its attachments.

If it is impossible to effect this by reason of its position and attachments, a tumor of considerable size may be sufficiently exposed, by means of an incision through the lip in the median line, carried into the nostril of the affected side alongside the septum nasi, and the cheek then dissected from the bone. When the growth is confined to the antrum—a polypus, for example—it may be reached and removed by means of this incision through the anterior wall of the antrum, or from within the mouth, without external incision through the palatal process.

When the growth is of great size, or when it belongs to the malignant or rapidly growing sarcomatous class of tumors, nothing less than excision of the entire upper jaw should be undertaken.

Prof. S. D. Gross gives the credit of the first removal of the upper jaw to Dr. Jameson, of Baltimore, Md., who successfully performed the operation in 1820; but the honor is by other writers given to Gensoul, of Lyons, whose case occurred in 1827. Lizars, Liston, Syme, Mott, Dupuytren, Heath, and others have repeatedly extirpated the upper jaw successfully, but the established position of the operation is, in great measure, due to important modifications suggested by Sir William Fergusson.

The special instruments required for excision of the upper jaw are strong, angular bone forceps, a small, strong saw with a movable back, chisels, gouges, and a Fergusson lion forceps.

The patient is placed in a recumbent position, and fully anæsthetized. An incision is carried in the median line through the lip to the nostril; thence around the ala and along the side of the nose to near the inner canthus of the eye, where it is joined by a curved incision begun over the zygoma, near the outer canthus, and carried along

the lower margin of the orbit. The large flap of integument thus marked out is rapidly dissected up and reflected outward. This incision, proposed by Fergusson, is preferable to that originally employed by Gensoul and Lizars, as it divides the facial arteries and nerves where they are of smallest size, and the resulting cicatrix is not nearly so unsightly. The tumor having been thoroughly exposed, an incisor tooth of the affected side is extracted, a small saw carried into the nostril corresponding to the growth, and the palatal process nearly or wholly divided. The nasal and malar processes, in the order named, are divided or deeply notched with the saw.

If the orbital plate is not involved in the disease, it should be preserved by making a section of the bone below the orbit by the saw horizontally applied. If the disease involves the upper part of the bone, it may be expedient to leave the alveolar process.

The bony attachments of the jaw are completely severed by the bone forceps; the jaw is firmly grasped by the lion forceps and forcibly depressed. The remaining attachments are thus brought into view, and their division is effected with the knife or the forceps. The infra-orbital nerve should be cleanly divided, and as much of the soft palate preserved as possible.

The jaw having been taken away, any remains of the growth should be removed with the gouge, and roughened points of bone cut off with bone forceps. Hemorrhage during the operation is usually trifling, in many cases not a ligature being required. The entrance of blood into the larynx may be effectually prevented by placing a small sponge, with string attached, in the back part of the mouth, and by frequently removing the accumulations with sponge and fingers. Preliminary ligation of the common carotid artery, or the performance of tracheotomy, together with the use of the trachea tampon as practised by Trendelenburg, are entirely unnecessary measures.

After the removal of the jaw all bleeding points that can be should be ligated, and Paquelin's thermocautery applied to vessels beyond the reach of the ligature. The cavity left by the removal of the jaw should be dusted over with iodoform and filled with cotton pledgets packed in with moderate tightness so as to support the cheek and repress the tendency to oozing of blood. The pledgets should be provided with strings, so as to facilitate removal.

The tegumentary flap is brought accurately into place, the wound closed with harelip pins at the lip, and in the rest of its extent with fine catgut or carbolized silk interrupted sutures. The dressing is completed by a compress of carbolized tow or absorbent cotton placed over the wound and retained by a few turns of a bandage. After the second or third day the cotton packing may be removed, and the cavity thoroughly cleansed daily with an antiseptic solution.

FIG. 2979.—Line of Incision in Excision of the Upper Jaw by External Flap. Fergusson's Method. (Erichsen.)

Results.—No operation of equal magnitude is followed by as great success as excision of the upper jaw. Erichsen says: "Of 17 consecutive cases collected by Hutchinson as having been practised in the London hospitals, it was successful in 14; and of 16 cases (10 of total and 6 of partial) done by Esmarch, 13 were successful (viz., 8 of the former and 5 of the latter)" ("Science and Art of Surgery," vol. ii., p. 585). In the practice of Prof. W. T. Briggs and the author, of 38 cases of total extirpation of the upper jaw (24 by the former, 14 by the latter) there has not occurred a single death.

The recurrence of the disease, after removal of the upper jaw, depends upon the character of the growth. When the operation is done for the removal of benign tumors, recurrence is rare; but when done for the removal of malignant tumors, epithelial or sarcomatous, recurrence is almost invariably the rule, no matter how thoroughly the operation may have been done, though the lapse of time between the operation and the reappearance of the growth varies within wide limits.

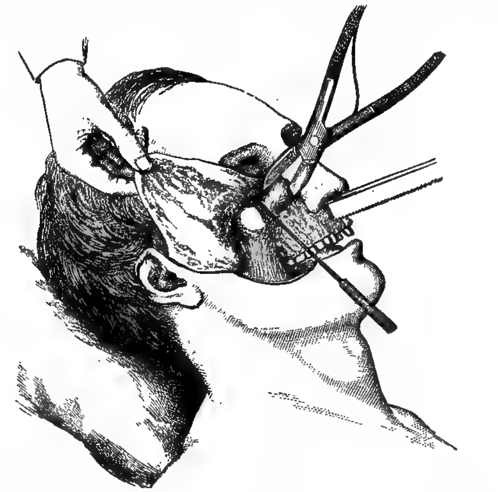


FIG. 2980.—Excision of Upper Jaw by Liston's Method. (Erichsen.)

Osteoplastic Section of the Upper Jaw is the term applied to an operation devised by Langenbeck, in 1859, for the removal of tumors situated behind the upper jaw but not involving that bone. The operation consists of the division of the attachments of the jaw in such a manner that the bone can be displaced downward or to the outer side sufficiently to expose tumors growing from the sphenoid or ethmoid bones, or from some of the fossæ between these bones and the palate bone. After removal of the tumor the jaw is replaced in its normal position, so that union of the divided bones will take place. The operation has been performed a number of times, with gratifying results, both in this country and in Europe.

Removal of Both Upper Jaws.—Excision of both upper jaws was first successfully performed by Heyfelder in 1844, since which time the operation has been occasionally repeated. It may be performed by carrying incisions from each commissure of the lips to the external angles of the eyes on both sides, and reflecting the flap, together with the nose, upon the forehead. The bony attachments of the jaws, the malar processes on each side, and the junctions of the bone with the nasal bones and vomer, are divided with the saw and forceps. The bones are then grasped with lion forceps and forcibly wrenched from their position.

Injuries and Diseases of the Lower Jaw.

The principal injuries and diseases of the lower jaw are dislocation and fractures, abscess, periostitis, necrosis, and the various kinds of tumors.

Dislocation of the Jaw.—This accident, not infrequent in middle age, is rarely met with in the extremes of life. It occurs more commonly in women than in men. Though in the majority of cases bilateral, the dislocation may be confined to one side.

As the subject is treated under the heading *Dislocations*, in volume III., it will not be necessary for me to enter into further details in this place.

Fracture of the Lower Jaw is a very common accident. It may be caused by either direct or indirect violence, though the former is by far the most frequent cause. Blows upon the jaw, falls from great heights, and kicks from horses may be mentioned as the most common causes of the accident.

When the alveolar border is involved in the fracture, as it nearly always is, the mucous membrane gives way and the fracture is, therefore, compound. It is the exception, however, for a wound in the skin to communicate with the fracture.

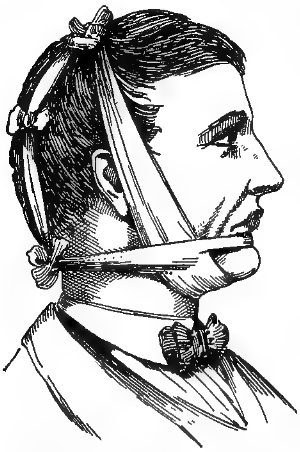


Fig. 2981. — Four-tailed Bandage as Applied in the Treatment of Fracture of the Lower Jaw. (From Heath.)

Not infrequently the bone is broken into two or more pieces, but comminuted fracture, in which the bone is shattered into many small fragments, is rare.

The jaw may be broken in any part of its extent, though, on account of its more exposed position, the body of the bone is the part most liable to the accident. Of 55 cases of fracture of the lower jaw, recorded by Hamilton, 52 were through the body.

Partial fractures, in which portions of the alveolar process are torn loose from the body of the bone, occasionally occur from extraction of teeth.

When the body of the bone is broken, the line of fracture is most generally in the vicinity of the canine tooth, where the jaw is naturally weakest, owing to the depth of the socket of that tooth and the proximity of the mental foramen.

The ramus of the jaw is less often fractured, on account of the direction of its axis, its great strength, and its protected position.

Fractures through the symphysis are very uncommon, because of the great thickness of that part of the bone.

The coronoid process may be occasionally broken by extreme violence directly applied.

A fracture of the neck of the condyle is of very rare occurrence.

When the jaw is broken near the symphysis, the line of fracture is almost vertical; when nearer the angle of the jaw, it is more oblique and, as pointed out by Malgaigne, the fracture occurs at the expense of the internal plate of the anterior fragment, and of the external plate of the posterior fragment.

Symptoms.—The symptoms are usually very obvious. The special signs of fracture—crepitus, preternatural mobility, and deformity—are all well marked. Pain, which is greatly increased by movements of the jaw, is invariably present. Irregularity in the line of the teeth is readily detected by the finger introduced in the mouth. The teeth which adjoin the fracture are loosened, often detached, and, in a case reported by Erichsen, a tooth became separated and lodged between the fragments. The mucous membrane is nearly always torn, giving rise to more or less hemorrhage. Saliva is secreted in excessive quantity, and, mingling with the discharges of the wound, decomposes, and gives rise to an offensive fetor most difficult to control, even by the most careful attention. When the fracture is double, the bone being broken on each side of the symphysis, the central fragment is displaced very much downward by the depressor muscles.

In single fractures near the symphysis the displacement of the fragment is usually great, while it is less the nearer the fracture is placed to the angle of the jaw. Fractures of the ramus are attended with very little displacement, owing to that part of the bone being covered and protected by the masseter muscle.

In fractures of the neck of the condyle the symptoms are pain at the seat of fracture, crepitation and displacement forward by the action of the external pterygoid muscle, as a result of which the chin is deflected to the injured side.

Considerable inflammation generally follows fractures of the jaw—the face and neck are swollen and infiltrated, and not infrequently troublesome abscesses form.

As possible complications of fractures of the lower jaw may be mentioned, hemorrhage from wound of the inferior dental artery, temporary paralysis of the lower lip and integument of the chin from laceration or contusion of the inferior dental nerve, necrosis, salivary fistula, and abscesses.

Simple fractures of the lower jaw heal in from thirty to forty days. Instances of non-union are extremely rare. The prognosis, both as regards deformity and the restoration of function, is good, for even in cases in which it has been impossible to obtain perfect apposition of the fragments, and union with some deformity has taken place, ultimately the deformity almost disappears, and but little evidence of the fracture may be detected.

Treatment.—Reduction in simple fracture is usually easily accomplished by conjoint manipulation, acting within the mouth upon the teeth and externally upon the border of the jaw.

When the line of fracture is very oblique and the fragments overlap and become locked, reduction is occasionally difficult, and, in a few recorded cases—one reported by Gurdon Buck, of New York—it became necessary to expose the bones at the seat of fracture by external incision, and to make a resection of the fragments before proper apposition of the broken segments could be accomplished.

When the fracture is simple and the tendency to displacement is slight, in many cases it is only necessary to maintain the fragments in place after reduction by means of a four-tailed bandage, which is so adjusted as to fix the lower jaw against the upper, thus utilizing the latter as a splint.

In addition to this bandage or the other forms of bandage used for this purpose, as Barton's figure-of-eight, or Gibson's bandage, a cup-shaped splint of pasteboard or gutta-percha moulded to the chin, may sometimes be advantageously used.

Fig. 2982. — Hamilton's Apparatus for Treatment of Fractures of the Lower Jaw. (From Heath.)

During the process of repair mastication and talking should be forbidden. Nourishment in fluid form should be administered, either by being sucked into the mouth between the teeth, or through a tube carried into the mouth behind the last molar tooth.

This simple method of treatment is most effectual when the fracture is uncomplicated.

Hamilton has devised an apparatus for the treatment of simple fractures which is admirably adapted to the purpose.

In regard to the management of loosened teeth, the idea formerly held, that they should be extracted as foreign bodies, is no longer entertained; they should be allowed to remain, as they soon contract new adhesions and become as firm as before. It may even be

advisable to tie them with wire or silk to adjacent firm teeth, until they have contracted new adhesions.

When the fracture is comminuted, or the tendency to displacement is very great on account of the obliquity of the line of fracture, this simple plan of treatment will prove ineffectual, and recourse must be had to one of the numerous ingenious mechanical supports that have been devised for such cases.

The old method of binding the teeth or the fragments together with wire or thread is objectionable, from the fact that the teeth soon become loosened by the strain thus brought to bear upon them and no longer afford adequate support.

An ingenious contrivance for wiring the teeth together, which in skilful hands is capable of achieving a certain amount of success, is Hammond's wire splint, which consists of a frame of strong iron wire made to surround the teeth, to a number of which it is fastened by smaller pieces of wire carried between the teeth. To insure accurate adjustment, the wire frame should be shaped upon a plaster cast of the teeth.

Various forms of interdental splints, made of gutta-percha, vulcanite, or metal, and moulded to fit over the teeth for some distance on each side of the fracture, are sometimes used. They are either intended to act as a lateral support while the lower jaw is firmly held against the upper, or they are fastened to the teeth or the bone by means of screws or metal wire, or they may be attached to an outside support by means of rods passing from the mouth to the outside.

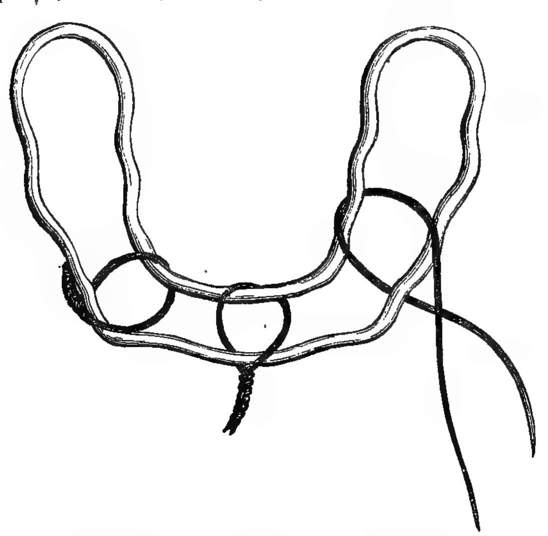


FIG. 2983.—Hammond's Wire Splint. (From Heath.)

Hamilton's method of making an interdental splint of gutta-percha is to take pieces of the gum of the proper size, and render them soft and malleable by dipping them in hot water. The pieces are then worked into the shape of wedges and carried between the teeth on each side, care being taken that the wedge extends on both sides of the fracture. The jaws are then pressed together until the lower border of the bone at the fractured point is smooth and held in position until the rubber hardens. Accurately fitting caps of the teeth are thus obtained.

Of this splint Hamilton says: "The 'clasp' applied over the crowns and sides of the teeth is not intended to act as an interdental splint; but by its lateral pressure it is expected to hold the fragments in apposition upon nearly the same principle as the ligature." [1]

Gunning and Kingsley, of New York, Bean, of Atlanta, Moore, Lonsdale, and Hill, of England, have all devised interdental splints consisting of a clasp for the teeth attached to an external support. These appliances have, in many difficult cases of fracture of the lower jaw, been of great service; but, on account of their complex mechanism and the necessity of considerable manipulative skill in adjusting them, they have never come into general use.

When the fracture is very difficult of management, as, for example, when the bone is broken in two places, and the middle fragment is drawn downward and cannot be maintained in place by any of the above methods; when the fragments overlap each other and are difficult to reduce, or when the fracture has a wound in the integument communicating with it, a more rational and certain mode of treatment consists in exposing the bone at the seat of fracture by an external incision, drilling holes in the fragments on each side of the fracture, and wiring the fragments firmly together (Fig. 2984).

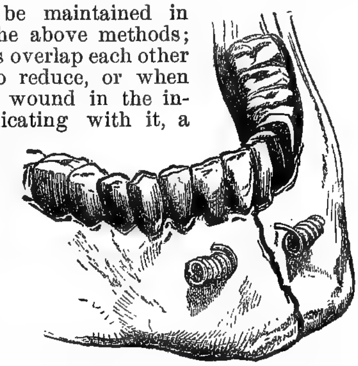


FIG. 2984.—Thomas' Method of Suturing the Fragments in Fracture of Lower Jaw. (From Heath.)

This method of treatment, advocated by H. Thomas, of Liverpool, as especially suited to compound fractures of the lower jaw, is equally appropriate to all fractures of that bone that present obstacles to the ordinary and more simple modes of treatment.

Thomas' method of operation is to expose the bone at the seat of fracture, bore holes through the fragments below the alveolus, on each side of the fracture, about one-eighth of an inch from the broken edges; a strong, pliant wire is passed through the holes thus made from one side to the other, and the ends of the wire are firmly twisted by means of a special instrument (Fig. 2985), called a key, devised for the purpose.

ABSCESS OF THE LOWER JAW may be acute or chronic. The symptoms, course, and termination of acute abscess of the lower jaw differ in no respect from those of acute abscess of the upper jaw, given in a preceding portion of this article.

Chronic abscess of the lower jaw may be caused by injury, by irritation of carious teeth, or it may result from suppuration of a dentigerous cyst.

The symptoms are obscure, there being slow, steady enlargement of the bone, sometimes with a dull, aching pain; more frequently, however, there is entire absence of pain. The accumulation of pus occurs between the osseous plates of the jaw, but it is seldom that the expansion is so great that the peculiar egg-shell crackling can be elicited by pressure. The slow increase in the size of the bone, and the firm consistence of the swelling in chronic abscess have, in a number of cases, led surgeons to remove portions of the jaw under the impression that they were dealing with solid tumors.

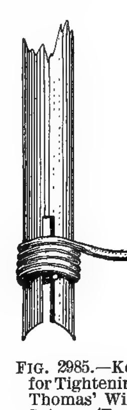


FIG. 2985.—Key for Tightening Thomas' Wire Suture. (From Heath.)

Treatment.—The treatment of chronic abscess is to evacuate its contents, which may usually be easily accomplished from within the mouth; but it is sometimes necessary to expose the swelling by raising a flap of skin, and then to apply the trephine to the bone.

PERIOSTITIS OF THE LOWER JAW may be either acute or chronic. The acute variety may be caused by the irritation of diseased teeth, mechanical injury, exposure to cold, or the action of certain medicines, as mercury and phosphorus. It may also arise, independently of any extraneous cause, in children of the scrofulous diathesis, or after the exanthematous fevers.

Acute periostitis of the lower jaw is very rapid in its

course, terminating in necrosis of the bone if not arrested promptly.

Symptoms.—The symptoms are swelling of the gums and the side of the face, a severe tensive pain in the part, worse at night; the teeth are raised in their sockets, and, when pressed upon, the most exquisite pain is elicited. Very frequently there is spasmodic closure of the jaw. The swelling often extends into the neck, and, when pus forms, pointing takes place beneath the jaw.

Treatment.—If the condition is recognized early, active treatment—such as the extraction of carious teeth, leeching the gums, free incisions, and hot fomentations by holding hot water in the mouth, may prevent the formation of pus.

When the process has become suppurative, the earlier the pus is evacuated the better.

When practicable the opening should be made from within the mouth, but most generally the evacuation can be better accomplished by external incision, as, aside from the fact that the abscess most frequently points in the neck, better drainage is thus afforded. Detergent injections into the cavity should be constantly employed. If necrosis occurs complete separation of the dead part must be awaited before removing it.

Chronic Periostitis of the Lower Jaw is usually the result of syphilis. It is almost painless in its course, and manifests itself in the nodes which appear upon the palate and the alveolar border. This form of periostitis yields readily to large doses of iodide of potassium.

Necrosis of the Lower Jaw is more frequently met with than is that of the upper, a fact most likely due to the greater vascularity of the latter.

Necrosis is the effect of unchecked suppurative periostitis, the accumulation of pus separating the periosteum from the bone, and in this way cutting off the vascular supply. Death of the bone ensues very rapidly after the establishment of the suppurative process, often in a few hours.

Necrosis may be complete, involving the entire thickness of the bone, or partial, when it is limited to the alveolar process.

It happens quite frequently that the external plate of the alveolar process becomes necrotic and is removed, while the internal plate remains intact and serves as an adequate support for the teeth.

Symptoms.—The symptoms of impending necrosis are severe pain, increased heat in the part, and rapid swelling of the gum and cheek. At this stage much may be done to arrest the death of the bone, or at least to limit the destructive process, by free incision of the gums, the extraction of carious teeth, leeching, hot fomentations, etc.

After necrosis has been established the pus finds an outlet by the side of loosened teeth, or wells up between the bone and the gum, which during the process become separated from each other; or it may burrow its way through the soft tissues to points beneath the body and near the angle of the jaw, where it points and is evacuated either spontaneously or by the surgeon. The discharge has the characteristic fetor of pus from dead bone, and in consequence of its constant entrance into the stomach, digestion is seriously interfered with. A probe introduced through a fistulous orifice readily comes in contact with denuded bone.

Treatment.—This consists, as in necrosis of the long bones, in the removal of the sequestrum, which, however, should never be undertaken until the separation of the dead from the living bone has taken place. It is especially important that this rule be observed in children before the permanent teeth have made their appearance, as a premature operation may not only seriously damage surrounding healthy bone, but also prevent the eruption of teeth that might otherwise have been saved.

If there are no external openings, and the ends of dead and detached fragments of bone project into the mouth, they may frequently be removed with the fingers or the forceps, only a small incision being required to enlarge the opening in the mucous membrane.

When the sequestrum is too large to be removed entire, it should be divided with bone forceps into two or more pieces, which can be taken away separately.

If at all practicable, the extraction of dead bone should be invariably effected through the mouth; but when the disease is extensive and a number of fistulous openings exist, or when it is impossible to operate within the mouth on account of the fixity of the jaw, the sequestrum may be reached and removed by an external incision so placed as to avoid disfiguration of the face as much as possible.

Necrosis of the jaws in children sometimes occurs upon the subsidence of the exanthematous fevers, especially scarlatina and smallpox. It comes on with aching of the teeth, swelling of the gums, and fetid breath; suppuration speedily ensues with all the symptoms of necrosis. A peculiarity that has been observed in this form of necrosis is the symmetrical manner in which it affects the bone. The disease is most generally limited to the alveolar process. The treatment differs in nowise from that of necrosis from other causes.

Necrosis of the jaws from severe mercurial salivation was formerly a common occurrence, when in the treatment of syphilis or other diseases it was thought necessary to induce ptyalism in order to obtain the best effects of mercury. Many supposed cases of this kind in children, however, really owed their origin to a scrofulous taint of the system, to cancrum oris, or to the poisonous effects of an exanthem. Fortunately, nowadays necrosis as the effect of the abuse of mercury is rarely seen.

The symptoms of necrosis from mercurialization are those of necrosis of the jaws from other causes, but aggravated in degree and with more constitutional disturbance. Large portions of the bone, not infrequently the entire bone, with portions of the cheek, were in many cases thrown off as a slough, giving rise to the most frightful deformity. To add to the pitiable condition of the patient, the jaws often became immovably fixed, so that deglutition was rendered very difficult.

Phosphorus Necrosis, arising from the injurious effects of the fumes of phosphorus upon the jaws, is a form of the disease to which the attention of the profession was called by Lorinzer in 1845. In this country the late Prof. J. R. Wood published an account of a case treated by him in Bellevue Hospital, New York, in 1856, remarkable from the fact that, after removal of the entire lower jaw, complete reproduction of the bone took place.

The disease occurs most frequently among workmen in lucifer-match factories, who are constantly exposed to the fumes of phosphorus. The disease is now seldom encountered, owing to precautionary measures adopted in the manufacture of matches.

The fumes of the phosphorus were supposed to gain access to the bone through carious teeth, so that persons with sound teeth enjoyed an immunity from the disease. Langenbeck and others held a different view, however, maintaining that the effects were produced through the system. Both jaws are about equally liable to the disease; but while in the lower jaw the entire body is generally involved, in the upper the necrosis is confined to the alveolar process and palate.

Symptoms.—The approach of the disease is very insidious, the symptoms at first being mild and hardly noticeable. As the morbid process advances all the symptoms are manifested in a most marked and exaggerated manner. The pain is excruciating, the swelling is very great, not confining itself to the immediate seat of the disease, but involving the side of the face and head; the discharge is profuse and very offensive; numerous abscesses form and open externally, forming fistulæ through which the probe can be made to touch dead bone. The health of the patient rapidly gives way, owing to the quantity of fetid pus necessarily swallowed, and to inability to eat sufficiently. Death frequently supervenes from exhaustion.

A characteristic feature of phosphorus necrosis is the peculiar deposit of pumice-like bone upon the sequestrum.

Treatment.—Before detachment of the dead bone occurs, it is important to sustain the vital powers of the patient by the administration of tonics and stimulants. Locally the mouth should be kept as free as possible of the discharges by the frequent use of detergent and antiseptic washes. When the sequestrum is fully detached, it should be removed from within the mouth if possible, otherwise by external incision, especial care being taken to preserve the periosteum as far as may be practicable.

Repair, after loss of the jaw from necrosis, differs in the two bones—in the upper no reproduction of bone takes place, and the gap is invariably left unfilled in adults; but in children, after necrosis following fevers, a hard fibrous tissue is formed which fills the gap, and may even serve as a support for artificial teeth.

In the lower jaw, especially in phosphorus necrosis, there is often the most abundant formation of new bone, which, however, is almost, if not entirely, absorbed afterward. In Dr. J. R. Wood's case, mentioned above, there was entire reproduction of the inferior maxilla, as shown in the celebrated specimen preserved in the Bellevue Hospital Museum.

Tumors of the Lower Jaw, especially cysts, central myeloid sarcoma, and epithelioma, are more commonly observed than those of the upper. They frequently reach a vast size, very often entirely filling the mouth, pushing the cheek far beyond its natural dimensions, stretching the mouth, separating the jaws, and sometimes extending far down upon the neck, and even upon the chest.

Cysts of the Lower Jaw may be single or multiple. Single cysts are sometimes connected with the fangs of perfectly sound teeth, or may originate from diseased or misplaced teeth.

The first are usually small in size and are occasionally extracted with teeth, to which they may be attached by very slender pedicles. Single cysts of this mode of origin may, however, reach a large size and cause expansion of a limited portion of the body of the jaw.

Single cysts may develop in the cancellous structure of the bone, having an origin connected with the teeth in a manner which is not clearly understood. As the growth increases in size, the bone yields and expands, so that it presents the appearance of a solid tumor. As the walls of the jaw become thinner by absorption, pressure causes the bone to crackle like parchment.

In the more advanced stage of the disease the bone is entirely absorbed, and fluctuation can be readily detected. The fluid contents of these cysts are of a dark color, and rich in cholesterin.

Multilocular cysts occur frequently in the lower jaw. They originate either in the canaliculi of the bone or from cystic degeneration of solid tumors. They are composed of a number of cysts of varying size, with more or less solid matter interposed. They are of slow growth, and may exist for a long period without impairing the health of the patient. Heath mentions a case of multilocular cyst, the history of which extended over a period of thirty years. Multilocular cysts are capable of reaching immense volume. The tendency of multilocular cysts to become solid epitheliomatous tumors, as pointed out by Mr. Frederick Eve, should be borne in mind in the treatment of such growths.

Dentigerous cysts have been more fully described in the section which treats of diseases of the upper jaw. When growing in the lower jaw they form globular tumors, become very large if unmolested, and are very liable to be mistaken for solid tumors.

Treatment.—In the treatment of single cysts, evacuation of the contents with excision of a portion of the cyst wall usually effects a cure.

When multilocular, the cyst should be laid open by incision, its contents scraped or gouged out, and the cavity packed with carbolized tow or absorbent cotton, with the view of establishing granulation.

The well-known tendency of multilocular cysts to recurrence makes the admissibility of excision of the portion of the jaw in which the growth is located worthy of consideration.

Dentigerous cysts should be evacuated, and the misplaced tooth found and removed.

Heath's case, in which the tooth was found embedded in the floor of the cyst some time after it had been opened, is unique.

Fibromata are growths of frequent occurrence in the lower jaw. They may be either of endosteal or of periosteal origin.

The endosteal form of fibrous tumors, as suggested by Heath in his excellent monograph on "Injuries and Diseases of the Jaw," most probably has an origin in the deposit, between the plates of the jaw, of inflammatory products which have undergone organization.

The tumor, as it increases in size, leads to expansion and thinning of the two plates of the jaw—the external to a greater extent than the internal,—and finally the bone undergoes absorption.

The periosteal fibroma grows most frequently at the junction of the gums with the teeth, and is only distinguished from fibrous epulis by its greater size.

Treatment.—If the disease is of long standing, the tumor very large, and the jaw more or less destroyed by the absorptive process, the growth should be removed with the segment of jaw that is involved. It may be possible to enucleate small tumors of this class. Advantage should always be taken of the fact that the external plate is principally involved to preserve the internal plate of bone, if practicable.

Enchondromata of the lower jaw are very rare. They occur chiefly in children, and are remarkable for their

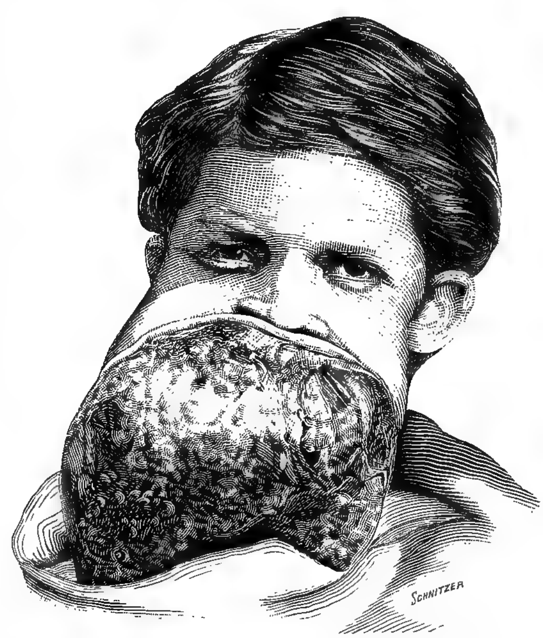


FIG. 2986.—Osteochondroma of the Lower Jaw. (From a photograph.)

slow, painless growth. Enchondromata occasionally grow to immense size, not infrequently causing death by interference with the functions of respiration and deglutition. These growths nearly always contain more or less bony deposits, and sometimes they are almost entirely transformed into bone, generally cancellous in structure, when they are appropriately termed osteochondromata.

The accompanying woodcuts are from photographs of a patient from whom Prof. W. T. Briggs, in 1878, removed the entire lower jaw for a tumor of this class. The patient was a boy twelve years of age, and the tumor had been growing for ten years. The enormous mass protruded from the mouth and extended as far down as the chest. The mouth was entirely filled by the tumor,

so that deglutition was very difficult and articulation imperfect. The health of the patient was only slightly impaired.

The specimen measured six inches in diameter, and weighed eight pounds.

As may be observed from the cut of the macerated specimen, more than half of the jaw-bone had been

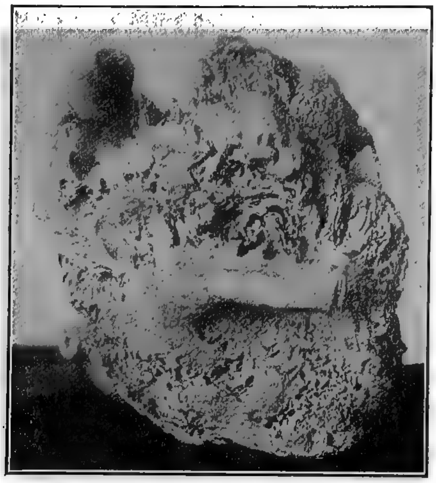


FIG. 2987.—Macerated Specimen of Osteochondroma Removed by Prof. W. T. Briggs. (From a photograph.)

absorbed. The second molar had been transported in the tumor half an inch above the alveolus.

The extraordinary size of the tumor may be estimated by the fact that the mouth had been so greatly distended that it was necessary, in the operation, to excise eleven inches of the patient's lip.

OSTEOMATA OF THE LOWER JAW may be either cancellated or of the kind known as ivory exostosis.

The cancellated osteomata most likely originate from the conversion of enchondromata into spongy osseous structure.

Ivory exostoses are frequently found near the angle of the jaw. Such tumors seldom reach very great size. They are as hard and compact as ivory, of painless, slow growth, and irregularly nodulated. These tumors may be removed by chiselling or gouging them out from the surface from which they spring. The probability of recurrence is small.

SARCOMATA.—The general appearance, symptoms, course, and treatment of this class of tumors are identical with those of similar affections of the upper jaw, given more fully in another part of this article. Sarcomata of the lower jaw are encountered more frequently and reach a larger size than those of the upper. Some of the largest tumors of the jaws have belonged to this type, among the largest recorded being one removed by Mr. Christopher Heath, which weighed six pounds four ounces.

The tendency to recurrence is one of the chief characteristics of sarcomata, and, therefore, in operations for their removal it should be the invariable rule to make sections through sound bone on each side of the growth.

EPITHELIOMATA OF THE LOWER JAW occur most frequently in old age, though they may occasionally appear in early life. The principal features of epithelial growths are rapid destruction of bone, tendency to form fungating masses that protrude in the mouth, glandular involvement, etc. Epitheliomata are sometimes secondary to epithelial growths of the lower lip, the disease in such cases extending directly from the lip to the bone.

The nature, diagnosis, prognosis, and treatment of epitheliomata of the lower and upper jaw are the same, though the chances of non-recurrence after removal are greater in the former, owing to its more isolated position.

The rule in excising portions of the lower jaw should be to go as wide of the disease as possible.

OPERATIONS UPON THE LOWER JAW.—Before proceeding to the performance of any operation the true nature of the disease should, if possible, be first ascertained. Rapid growth, infiltration of adjacent tissue, involvement of neighboring glands, the soft, pulpy consistence of the tumor, tendency to ulcerate, and impairment of the patient's health, should serve to distinguish malignant from innocent diseases.

It is important, also, to differentiate between the cystic and solid tumors, which may be readily done if the cyst is of large size and its bony walls have become so thinned by absorption as to yield the characteristic crackling upon pressure.

If doubt exists as to whether the growth is cystic or solid, an exploratory incision or puncture will usually clear up the diagnosis.

The special treatment appropriate to each variety of tumor of the lower jaw has already been given with the separate description of the various affections.

EXCISION OF THE LOWER JAW was first performed by Dr. W. H. Deadrick, of Tennessee, in 1810, although credit has usually been given to Dupuytren, whose case occurred in 1812. Dr. Deadrick's operation was undertaken for the removal of a large enchondroma, and was entirely successful.

When the tumor grows from the alveolus, and does not involve the entire thickness of the jaw, it is often possible to remove it from within the mouth with strong bone forceps and gouge, without making a complete section of the bone.

If the tumor is large and occupies the body between the symphysis and angle, as is most frequently the case, excision of a segment of the jaw between those two points is generally required. This operation has been performed from within the mouth, notably in two cases by Mr. Maunder, referred to by Heath, but the operation is a very difficult one, especially in cases in which the neoplasm has attained any volume. The greater ease and thoroughness with which the bone may be excised by the external operation more than counterbalances the advantages obtained by operating so as to avoid a scar.

The operation for removal of the jaw between the angle and the symphysis is performed as follows: The patient is thoroughly anæsthetized, his head raised somewhat, and an incision made directly down upon the bone from the symphysis to the angle beneath the lower border of the bone. If the tumor is so large as to require more room than is afforded by this incision, another incision may be made in the median line through the lip and joining the anterior extremity of the first. The facial artery and vein will be divided by the first incision at the point where they cross the border of the jaw, and should be ligated before proceeding further with the operation. The soft parts are now rapidly dissected from the bone, and the tumor is thoroughly exposed to view. If the tumor is innocent, the surgeon should ascertain at this stage of the operation whether it can be removed without sacrificing the entire thickness of the jaw. If feasible, the growth should be enucleated or gouged out of its bed, and the lower border of the jaw left intact. If excision is determined upon, the internal surface of the bone should be cleared of its attachments with knife and elevator.

If the extent of the disease makes it necessary to divide the geniohyoid and geniohyoglossus muscles, a stout ligature should be passed through the tongue, by means of which it may be drawn out and thus prevented from falling back into the pharynx and causing suffocation, as has happened in a number of cases.

A tooth on each side of the tumor having been extracted, a saw is now applied to the bone at the points at which the jaw is to be divided, and the bone partially severed at each point. The sections of the bone may now be completed with bone forceps and the part removed. The fragment of jaw with morbid growth attached having been removed, all bleeding points should be ligated, the wound thoroughly irrigated with carbolized or iodinized water, and its surface dusted over with

iodoform. The flaps of skin may now be brought in place and the wound closed with interrupted sutures of catgut or carbolized silk, and a drainage tube inserted at the most dependent angle of the wound. A light compress of tow or cotton, placed over the wound and retained by a few turns of a bandage, will complete the dressing. The ligature through the tongue should be fastened to a part of the dressing or to the cheek with a piece of adhesive plaster, and not removed for several days, when the tongue shall have formed new adhesions. The patient must be fed for some days upon a liquid diet, which frequently has to be administered through a tube. The mouth should be carefully cleansed by the frequent use of an antiseptic wash.

The dental artery in the divided bone may give rise to troublesome hemorrhage, to check which it may be necessary to apply the actual cautery, or to plug the dental canal with a piece of soft wood.

If the tumor encroaches upon the angle and ramus of the jaw, removal of half the jaw, with disarticulation, should be done; for even were the greater portion of the ramus sound, if it were left in place the powerful contraction of the temporal and external pterygoid muscles would tilt the fragment forward in such a position as to render it a constant source of irritation and discomfort.

For the removal of half the jaw an incision should be carried under the border of the bone to the angle, where it is joined by a vertical incision along the posterior border of the ramus to the level of the lobe of the ear. A third incision, from the inner extremity of the first incision vertically through the lip, may be required in cases of large tumors.

Occasionally the incisions cannot be made in conformity with any given rules, but must be adapted to suit the case, and in exceptionally large tumors it may be necessary to take away large segments of the skin.

The flap of skin should be dissected from the surface of the tumor, an incisor tooth extracted at the point at which the section of bone is to be made, and the jaw entirely divided with a small saw. Before proceeding further, the tongue should be secured in a looped ligature. The bone should now be seized with the lion forceps and drawn forcibly outward, in order that the attachments to the buccal surface of the bone may be divided. Especial pains should be taken to keep the edge of the knife directed against the bone, in order to avoid wounding anteriorly the submaxillary gland and, nearer the articulation, the internal maxillary artery.

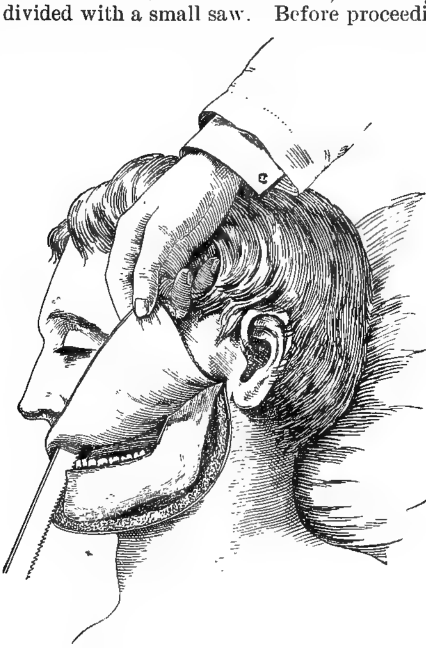


FIG. 2988.—Excision of Lower Jaw—Soft Parts Raised. (Erichsen.)

With the fragment still in the grasp of the forceps, it should be forcibly depressed so as to cause the coronoid process to start forward and thus permit of the division of the temporal muscle. The joint being exposed, the knife should be applied over it, by which the capsule is opened and the condyle released. In this step of the operation care should be taken not to twist the fragment of jaw too far externally, as the internal maxillary artery may be thus pressed around to the front and wounded at the same time the capsule is opened. In very large tumors it is frequently impossible to reach the coronoid process. Under these circumstances the ramus should be divided as high up as possible, leaving the coronoid and condyloid processes to be dissected out after removal of the tumor. The few remaining attachments of the soft parts to the bone having been divided, the jaw is removed.

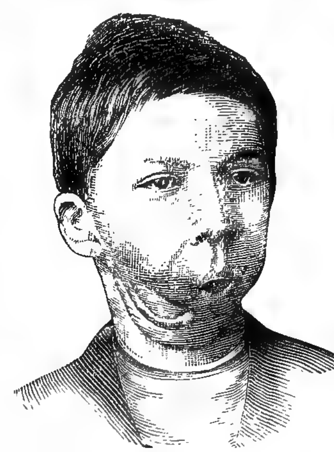


FIG. 2989.—Showing the Degree of Deformity left After the Removal of the Entire Lower Jaw. (From a photograph.)

The close proximity of the internal maxillary artery to the neck of the condyle makes it very liable to be wounded, and it is therefore always necessary to observe the greatest caution in disengaging the condyloid process. When the artery is divided hemorrhage is very profuse, necessitating the immediate application of a ligature, or if on account of the great depth of the artery this cannot be done, the temporo-maxillary artery should be ligated.

To prevent the remaining half of the lower jaw from falling inward, it has been proposed to fasten the teeth of the lower to those of the upper jaw by means of wire or metallic caps, but the measure has not been attended with much success.

The removal of the entire lower jaw, from one articulation to the other, for morbid growths is very seldom required on account of tumors, but in cases of phosphorus necrosis it was frequently performed. When excision of the entire bone is required on account of tumors, the incisions can be made to follow no special set of rules, but should be made to suit the requirements of the case. For example, in the removal of the large osteochondroma by Prof. W. T. Briggs, mentioned above, one incision was carried from the commissure of the lips (as near as could be judged) to the articulation of the side from which the tumor had commenced, and a second incision was then commenced on the opposite side and carried through the lip vertically downward for several inches, and thence in a curvilinear direction under the tumor to the outer termination of the first incision, thus removing a large segment of skin and lip.

The results of operations for the removal of portions or the whole of the lower jaw are equally good as in excisions of the upper jaw. "Of 419 cases tabulated by Prof. O. Weber, only 83, or 20 per cent., perished. Of these, 246 were excisions in continuity, with 46 deaths; 153 were disarticulations of one-half the bone, of which 117 recovered, and 20 were extirpations of the entire jaw, with only 1 death. Pyæmia, erysipelas, and exhaustion were the principal causes of death." [2]

Deformity after removal of portions of, or even the entire, jaw is remarkably slight (see Fig. 2989). The

gap left by the removal of the bone is filled with a thick, firm band of fibrous material, which takes the shape and general direction of the removed bone, and is in many cases sufficiently firm to support artificial teeth.

Closure of the Jaws may exist in one of two forms, viz., temporary or spasmodic, and permanent or organic.

Spasmodic closure of the jaws is most frequently due to firm contraction of the masticatory muscles, especially the masseter and the internal pterygoid, superinduced by prolonged irritation of branches of the third division of the fifth pair of nerves.

The most common cause of this condition is the difficulty that sometimes attends the eruption of the wisdom tooth, either from the fact of its being misplaced or because the space between the second molar tooth and the ramus of the jaw is insufficient. Among other causes of spasmodic closure may be mentioned alveolar abscess in the vicinity of the last two molars, suppurative tonsillitis, necrosis of the jaws, etc.

Treatment.—The treatment of this affection is obvious, viz., to remove the cause. When the condition arises from difficult eruption of the wisdom tooth, the patient should be thoroughly anæsthetized and the jaws forcibly separated by a screw-gag or lever, in order that access may be had to the seat of trouble. If the wisdom tooth is presenting normally, it may be sufficient to incise the gum freely or to extract it. Generally it is necessary to remove the second molar, in order that the wisdom tooth may have room to emerge. The cause of the irritation having been removed, the function of the jaw is in a short time completely restored.

Permanent or Organic Closure of the Jaws is a far more serious affection than the spasmodic form, the management of which often taxes the patience and skill of the surgeon, as well as the endurance of the unfortunate sufferer, to the utmost. These cases may be conveniently divided into two classes, namely: those arising from diseases of the temporo-maxillary articulation, and those which have their origin in ulcerative action and cicatricial contraction in the perimaxillary soft tissues.

The Diseases of the Temporo-maxillary Articulation which, by causing fibrous or osseous ankylosis, lead to permanent closure of the jaws, are acute and chronic arthritis.

Acute Arthritis may follow mechanical injury—for example, blows upon the side of the face, dislocations, or fractures that extend into the joint—or it may supervene upon the exanthematous fevers in connection with diseases of the middle ear.

Symptoms. — The symptoms of acute arthritis of the temporo-maxillary articulation are pain, redness, heat, and swelling and stiffness of the jaw, sometimes amounting to entire closure of the jaws. If suppuration occurs, the pus may escape through the external auditory meatus or by means of an opening in the overlying skin.

Treatment.—The treatment of this condition should be rest to the joint by causing the patient to abstain from mastication, the application of leeches over the joint, hot fomentations, and evacuation of pus as soon as formed.

Chronic Rheumatic Arthritis of the temporo-maxillary joint is essentially a disease of old age, fortunately, however, rarely met with. It may affect one or both sides, but is more frequently unilateral.

Symptoms.—The symptoms are gradual enlargement of the condyle, which may often be plainly felt beneath the zygoma, pain on opening the mouth, and a peculiar creaking in the joint on moving the jaw, plainly perceptible to the patient. The neighboring lymphatic glands are enlarged. The face is distorted, the chin being inclined to the sound side when the disease is unilateral, carried prominently forward when bilateral. The pathological changes are the same as those of chronic arthritis of any other joint—the articular cartilage undergoes disintegration and absorption, the glenoid cavity is enlarged, the interarticular cartilage disappears, the eminentia articularis is levelled down so as to permit of partial dislocation, and the neck and head of the jaw are thickened and enlarged. The muscles are in a state of tonic contraction in the effort to keep the inflamed joint surfaces in contact, and, as a consequence, stiffness of the jaws is always present to a greater or less degree.

Treatment.—In the treatment of this disease little is to be hoped for from the action of medicines, though active counter-irritation over the joint and the exhibition of increasing doses of the iodide of potassium have been recommended.

In the Transactions of the American Medical Association of 1881, Dr. D. H. Goodwillie, of New York, describes an ingenious method of making extension in the treatment of this disease, which in his hands yielded the most encouraging results. The apparatus consists of an interdental splint which separates the posterior teeth while the anterior remain free, and which is made to act as a fulcrum when the chin is elevated by means of elastic straps attached to a skull-cap, thus serving at the same time to keep the joint surfaces apart and to hold the jaws immovable.

Ankylosis of the Jaw, the result of arthritis, may be fibrous or osseous. No matter whether the disease is unilateral or bilateral, mastication is impossible.

The diagnosis between the fibrous and osseous varieties can be ascertained only when the patient is under the influence of an anæsthetic.

If the ankylosis is dependent upon the presence of fibrous tissue, the jaws may be forcibly separated, and the adhesions broken up by means of a screw-gag made for the purpose, or of levers and a wedge introduced between the teeth to keep the jaws apart. The tendency of the parts to become fixed again renders the daily repetition of this process necessary for months, and even for years. Even with the most constant care on the part of the surgeon, and the fullest co-operation of the patient, the result is very seldom satisfactory, and at the present time is rarely resorted to, except as after-treatment to more radical operations.

Division of the fibrous bands by a tenotome passed through the mouth into the articulation has been frequently done, with some showing of better results.

In both fibrous ankylosis, in which so little is to be hoped for from mechanical treatment, and in osseous ankylosis, or synostosis, the method which promises the best results is excision of the condyle with a portion of the neck of the jaw, and establishment of an artificial joint. Less radical measures, as Esmarch's operation, in which a wedge-shaped segment of the bone is removed, and that of Rizzoli, in which simple section of the bone is made—both with a view of establishing a false joint—are occasionally practised for the relief of ankylosis, but not with the same measure of success that follows excision of the joint.

Esmarch's and Rizzoli's operations are more applicable to the variety of closure of the jaw which depends upon cicatricial formation in the buccal mucous membrane, and will be described later on.

The operation of excision of the joint is performed as follows: "An incision is begun at the lower margin of the zygoma, close in front of the temporal artery where it adjoins the ear, and carried forward along the zygoma one and a quarter inches, the tissues being divided, layer by layer, until the bone is reached. A second incision, involving only the skin, is then carried from the centre of the first directly downward for about an inch. The soft parts are carefully separated with elevator and knife from the margin of the zygoma and the outer surface of the joint, and drawn downward with a hook, thus preserving the parotid nerves and vessels from injury. The neck of the condyle is then freed by working around in front and behind with a small elevator, keeping close to the bone so as to avoid injury to the internal maxillary artery, and finally divided with a chisel. If there is bony union between the condyle and temporal bone, the chisel must be again used to separate them, its edge being kept directed somewhat downward so as not to break through into the cavity of the cranium." [3]

Permanent Closure of the Jaws may be due to cica-

tricial contraction following extensive ulceration and sloughing of the buccal mucous membrane.

This condition may be the result of cancrum oris, profuse ptyalism, or necrosis. In reference to closure of the jaws from the excessive employment of mercury, Gross says: "Such an occurrence used to be extremely frequent in our Southwestern States during the prevalence of the calomel practice, as it was termed, but is fortunately diminishing. Children of a delicate, strumous constitution, worn out by the conjoined influence of mercury and scarlatina, measles, or typhoid fever, are its most constant victims; but I have also seen many examples of it in adults or elderly subjects. In the worst cases there is always extensive perforation of the cheeks, permitting a constant escape of saliva and inducing the most extensive disfigurement."[4]

When the mucous membrane of the cheek, from one alveolus to the other, is involved, the cheek is bound so closely to the jaw that all movements of the jaw are rendered impossible, and often the space between the teeth and the cheek is so limited as scarcely to admit the passage of a probe.

Frequently the new tissue has bone developed in it, which occasionally is present in the shape of an osseous bridge extending from one jaw to the other, thus serving to bind the bones even more closely together.

The condition of the patient is pitiable in the extreme, as food can be carried into the mouth only in fluid form, or by being rubbed against the teeth.

Treatment.—Attempts at relief of this condition by division of the cicatricial tissue and forcible separation of the jaws have proved unsatisfactory, since as soon as healing had taken place contraction of the new cicatrices occurred.

Excision of the nodular tissue entirely, and transplantation of healthy mucous membrane, as proposed by Dieffenbach, or of healthy skin, as practised by Jaesche, is nearly always impracticable, on account of the difficulty of obtaining healthy mucous membrane or skin near enough to be utilized.

To separate the adhesions from the bone, and, in order to prevent readhesion, to adjust metal shields worn over the teeth to keep the surfaces apart, and at the same time to keep up forcible separation, is a method of treatment that is not only most trying to both surgeon and patient, but one that has never, even when fairly tried for a long time, given satisfaction.

Dieffenbach's operation of making an artificial joint behind the contraction, by simple section of the bone, has proved inefficient on account of the liability of the divided bones to reunite.

The operation proposed by Esmarch, of Kiel, in 1855, of establishing a false joint in front of the contraction, by excising a wedge-shaped piece of the bone, is the most rational treatment yet devised for closure of the jaws depending upon contraction of cicatricial tissue. Of course this operation is applicable only to cases in which the disease is limited to one side.

Esmarch's operation is superior to the method of Rizzoli, which consists in the establishment of a false joint in front of the contraction by simple division of the jaw, on account of the tendency of the divided bones to reunite.

Esmarch's operation is thus performed: "An incision is begun at the angle of the jaw and carried two inches along the lower border. A narrow strip of bone is then cleared on both sides up to the edge of the gum, a tooth drawn if necessary, the chain-saw passed around the bone through the incision, and the section made. The anterior fragment is then depressed and protruded through the wound, and a wedge-shaped piece, from one-third to one-half an inch in width at the widest part, cut off with cutting forceps."[5]

Dr. J. Ewing Mears, of Philadelphia, in vol. i. of the Transactions of the American Surgical Association, reported a case in which he made a false joint for closure of the jaws from a gunshot wound by resection of a portion of the ramus of the jaw, together with the coronoid and condyloid processes, and obtained a good result.

In the discussion that followed Dr. Mears' paper, Prof. W. T. Briggs reported a case of closure of the jaws from double synostosis resulting from arthritis, caused by a fall upon the chin, in which he removed the anterior portion of the body of the jaw. In this case the object of treatment was to obtain an avenue into the stomach, and excision of the jaw was the only method by which this object could be effected, inasmuch as the cause of the condition existed on both sides—the lower jaw was undeveloped, and occupied a position some distance behind the upper jaw; the lower teeth were buried in the mucous membrane of the palate, and the masticatory muscles had degenerated into fibrous tissue from long disuse.

In such extreme cases of closure of the jaw, excision of a portion of the bone is the only resort of the surgeon.

Charles S. Briggs.

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[5] Stimson's Manual of Op. Surgery, p. 191.
[6] Stimson: Fractures and Dislocations.

JECORIN.—Jecorin is a complex organic body containing phosphorus and sulphur, and which resembles in many respects lecithin. It was first prepared by Drechsel[1] from the liver of the horse in the following manner: The liver was extracted by cold dilute alcohol; the alcohol was evaporated at a low temperature, and the residue shaken several times with absolute alcohol, by which many impurities were removed while the jecorin remained undissolved. The jecorin was then taken up in ether containing water and precipitated by absolute alcohol; by repeating these operations several times the jecorin was finally obtained in pure form.

By drying in vacuo over sulphuric acid jecorin is obtained in the form of a light yellow, amorphous mass, which is so hygroscopic that when exposed to the air it becomes soft and sticky. On the addition of more water it swells and finally forms a turbid solution; after evaporation on the water-bath it is insoluble in ether as well as in water.

Jecorin is precipitated from its solutions by concentrated hydrochloric acid, copper acetate, and silver nitrate. The silver precipitate is soluble in an excess of jecorin, the solution being opalescent; on adding ammonia and warming the solution becomes ruby red.

Drechsel found the following elementary composition for the jecorin from the horse's liver: C 51.4, H 8.2, N 2.86, P 3.5, S 1.4, Na 2.72. Drechsel proposed the following formula from the above analysis: $C_{105}H_{185}N_5SP_3Na_3C_{46}$.

Baldi[2] isolated a substance having properties very similar to those of Drechsel's jecorin from the liver of the rabbit and dog; analysis of the latter preparation gave results somewhat different from those obtained by Drechsel: C 46.88 to 46.89, H 7.81 to 8.09, N 4.36 to 4.88, S 2.14 to 2.70, P 2.29 to 2.75, Na 5.72.

These analyses show that jecorin may be regarded as the sodium compound of an acid closely related to the "protagons."

When jecorin is boiled with sodium hydroxide and copper sulphate the latter is reduced, showing the presence of a sugar-like substance. When jecorin is warmed with sodium hydroxide alone, stearic and other fatty acids are split off; the soaps so produced form a gelatinous mass on cooling.

On boiling jecorin with barium hydroxide, cholin and glycerin-phosphoric acid, as well as fatty acids and a sugar (probably dextrose), are formed; this decomposition shows that jecorin is very similar in composition to lecithin.[3]

Baldi, making use of the method of Drechsel, found jecorin in the spleen, muscle, and human brain, and in

the blood. The jecorin from the blood seems to differ somewhat from that obtained from the liver; when the former is saponified the solution does not set to a jelly on cooling.

Recently Manasse has found in the suprarenal gland of the beef and horse a substance having many of the properties of jecorin; it did not, however, reduce alkaline copper-sulphate solution, except after prolonged boiling with sulphuric acid, and it did not lose its solubility in ether by drying. Analysis showed that it differed considerably in composition from the liver jecorin: C 41.43, H 7.16, N 0.3, S 1.8, P 4.44.

From the various facts stated above it seems probable that there are several jecorins.

Baldi's discovery of jecorin in the blood has aroused considerable interest among physiologists and physicians. It had been shown by Otto[4] that the blood contains a reducing substance in addition to dextrose; since Baldi's discovery of jecorin in the blood it has been customary to attribute all, or the greater part, of the reducing power of the blood (after removal of the dextrose) to jecorin. Some authors[5, 6] have gone so far as to suppose that jecorin is really simply a combination of lecithin and dextrose; that very little dextrose occurs free in the blood, but that it may be split off from the jecorin under special conditions. Bing[7] states that the blood of animals in which the "diabetic puncture" was made showed a considerable increase in the amount of jecorin in the blood, while the sugar showed no constant increase. Extirpation of the pancreas was followed by an increase of both jecorin and sugar. Kolisch and Stejskal[8] at one time held that in cases of diabetes mellitus the sugar of the blood was not increased, the apparent increase being due to an increase in the quantity of jecorin.

In most of the experiments in which the significance of jecorin in the blood has been discussed, the jecorin was not determined directly; all the reducing substances which were not extracted by water, but which were extracted by ether, were reckoned as jecorin. Mayer,[9] however, has recently shown that normal blood contains glycuronic acid. The combination of glycuronic acid occurring in the blood is soluble in ether, is not fermentable, but reduces Fehling's solution on boiling, *i.e.*, it gives the reactions which have usually been held sufficient to show the presence of jecorin. As all previous observers have neglected the possibility of the occurrence of glycuronic acid in the blood, it is evident that much more work is necessary before any conclusions can be drawn as to the significance of the occurrence of jecorin in the blood in either health or disease.

In making determinations of both lecithin and sugar in the various organs, it is necessary to take account of the jecorin. Thus the quantity of lecithin in an organ is usually determined by the phosphorus in the ether-alcohol extract; such extracts, however, contain jecorin, and as the latter contains phosphorus the results are too high for lecithin. In a similar manner the jecorin may vitiate the quantitative estimations of sugar, especially in such an organ as the liver, where it occurs in such abundance.

Reid Hunt.

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JEMEZ HOT SPRINGS.—Bernalillo County, New Mexico.

Post-Office.—Archuleta.

These springs are located in the beautiful Jemez Mountains, 45 miles from Albuquerque, with which they are connected by daily stages during the summer months. There are two groups of springs, known as the upper and the lower. The upper group at Archuleta is most frequented. These springs are located in the San Diego Canyon, 620 feet above the level of the sea. They are forty in number, and range in temperature from 70° to 105° F. They are chiefly saline in character. The lower group, two miles south, are ten or more in number, and have temperatures ranging from 94° to 168° F. They are also saline.

James K. Crook.

JEQUIRITY.—*Abrus, Love Pea, Prayer Beads, Jumble Beads, Crab's Eyes. Abrus* L. (fam. *Leguminosæ*) is a genus of six species, related to the lentil and the pea, known to medicine by the species *A. precatorius* L., which is indigenous in British India and very widely distributed in the tropics of both hemispheres. The plant prefers a light or sandy soil, and its slender, woody stems climb high over shrubbery in the edges of forests. The fruit resembles a miniature pea-pod, a little more than an inch in length, and containing from four to six seeds. The roots have been employed as a substitute for licorice under the name of wild or Indian licorice. The leaves possess the same property, containing considerable glycyrrhizin. The seeds are better known than the root, under the name jequirity. They are a quarter of an inch in length, elongated-globose, smooth, shining, bright scarlet, a black spot surrounding the hilum. A black form, with white spot, and a white form with black spot, occasionally occur. They are largely employed for rosaries, ornamental beads, children's toys, and in India, under the name of *retti*, for weighing. They have also been used in India for criminal poisoning, usually of cattle. For this purpose the seeds are crushed and worked into a paste with water. This paste is rolled into a needle-pointed form, mounted upon a stick and used to prick the skin of the fated animal, which quickly succumbs to heart failure.

In South America originated the practice of painting a watery infusion upon granulated eyelids, by which suppuration was induced and the granulations were removed.

The active agent was at first supposed to be the bacteria which appear after a time in the infusion. Later, this theory was disproved, and the properties were reported to reside in an albuminous substance called *abrin*. This was later found, by Drs. Sidney Martin and R. Norris Wolfenden, to be a mixture, and was by them separated into two albuminous bodies, a globulin one-fifth as poisonous as the venom of the common adder and an albumose one-sixth as strong as the globulin. These poisons are destroyed by heat. Their effect resembles that of snake venom, the temperature falling greatly and the blood remaining semi-fluid after death. It is by no means certain, however, that this resemblance is not superficial.

Jequirity has been recommended only for local use. It acts as a powerful irritant to mucous membranes. If taken internally, uncooked and concentrated, it produces vomiting and purgation, the fæces being often bloody. Forty seeds produced these symptoms, with partial collapse, but recovery followed. If it is applied to the eyelids, inflammation quickly ensues, with suppuration usually on the third day. The inflammation is characterized by great swelling and pain. If the applications are continued, there is great systemic disturbance also. The applications have been continued by most practitioners for from three to ten days. Upon their discontinuance, the symptoms usually subside quickly and then disappear, with the removal, or great reduction, of any previously existing pannus. The effect upon conjunctival granules is not so great. In unfavorable cases, ulceration of the cornea and sometimes loss of the eye have resulted, and in severe cases the inflammation has extended over the entire face and even to the salivary glands. Most of such accidents have resulted from the use of too concentrated or bad preparations, or from careless treatment. Nevertheless, the remedy has come to be regarded as a heroic one, and is now not frequently employed. Either an infusion or a powder may be employed, the strength ranging from three to six per cent., and it should be freshly made. The powder should be dusted

upon the inner surface of the lids, or the infusion applied with a camel's-hair brush, or even dropped into the eye. *Henry H. Rusby.*

JOINTS, CHRONIC DISEASES OF.—Chronic diseases of the joints can for the most part be considered under one of the two following headings:

I. Diseases affecting the synovial membrane.

II. Diseases affecting the bone.

Other affections, such as those accompanying constitutional affections and miscellaneous conditions demand separate consideration which will be classed for convenience as

III. Miscellaneous.

I. DISEASES AFFECTING THE SYNOVIAL MEMBRANE.—Chronic inflammation of the synovial membrane is either a continuance of the inflammatory process described under acute synovitis (see article on *Synovitis, Acute*), or it may be, primarily, subacute or chronic. After persisting it is characterized by thickening of the synovial membrane, an increased secretion, and retrograde metamorphosis of the connective tissue. This metamorphosis may develop granulation tissue and attack the cartilage and bone in a degenerative and destructive process, or it may terminate in an alteration and cicatricial change of all the tissues (these have been described in the article on *Arthritis Deformans*), or the process may be chiefly limited to the synovial membrane.

FIG. 2990.—Double Chronic Synovitis of Knees.

(*a*) *Chronic Serous Synovitis* (Dropsy of the joint, Hydrarthros, Hydrarthrosis, Hydrops articulorum chronicus).—The pathological appearances of chronic synovitis vary much, but an increased amount of fluid is always present. Certain cases show no pathological changes beyond this increase of fluid for a long time, and these are the cases which have given rise to the names hydrops, hydrarthron, etc.

The change coming next after the increased vascularity and thickening of the synovial membranes which occurs in acute synovitis is an hypertrophy of the synovial fringes. This varies from a slight hyperplasia to a condition in which fibrous tissue change has set in, and solidified them into a multitude of small fibrous polypi. Meantime the subsynovial tissue has hypertrophied and thickened, to even an inch in some cases, and if the fluid has been long in the joint the synovial membrane and the parts below it look light yellow, pulpy, and boggy. If the effusion has been extreme the capsule has either become enormously thickened or has given way and become much distended. If so, the lateral and internal ligaments, weakened by the continual tension and soaked by the contained fluid, have also stretched, and lateral motion may be found in the knee-joint, even to the extent of 60°. When thickening of the capsule has predominated, cartilaginous and even bony plates may be found in the tissue. The synovial membrane in certain cases begins to encroach upon the cartilage. Normally, it runs into the cartilaginous border for 2 or 3 mm., but now the hypertrophied membrane sends out processes which creep in still farther, as pannus does on the cornea. It may go on to the formation of granulation tissue, but it is not likely that it will. Purulent cases generally follow another type, as will be seen later (Fig. 2990).

Chronic serous synovitis, which begins slowly and not from an acute affection, and which is characterized by the slight pathological changes mentioned above, is an affection whose cause is wholly obscure. It occurs oftenest in young men; it is not associated ordinarily with the rheumatic or any other diathesis, and any attempt to assign a cause is mere speculation. Such cases are oftenest marked by the occurrence of pronounced hypertrophy of the synovial fringes, and a tendency to connective-tissue formation. One phase of the affection is represented by the intermittent form in which the effusion occurs at more or less irregular intervals without obvious cause.

Arthrite Plastique Ankylosante.—There is a form of acute and subacute synovitis which has been described under the acute forms as dry synovitis. This condition is sometimes found as well in the chronic class. It represents an inflammation with a small exudation very rich in fibrin. It is apt to be associated with an infectious cause, as in gonorrhœa. The destruction of the cartilage is slight, and the ends of the bones are soldered together directly by the organized exudation.

II. JOINT AFFECTIONS BEGINNING IN BONE.—The type of degenerative ostitis can be described in a very few words — hyperæmia of the vessels, infiltration from the distended capillaries, and the formation of large spaces (lacunæ of Howship), with absorption of the trabeculæ; fatty degeneration of the bone cells, and their final replacement by embryonic tissue. The mechanism is, then, at hand for any amount of destruction. The greater part of degenerative ostitis of the ends of the long bones follows one type, which is now called tuberculous.

FIG. 2991. — Tumor Albus. Small focus in upper epiphyseal line of tibia. Synovitis of joint but no tuberculous process apart from focus as noted. Death from miliary tuberculosis. *a*, Epiphysis; *b*, primary focus; *c*, shaft. (Nichols.)

This type of disease presents itself ordinarily in the spongy tissue of the epiphyses of the long bones, oftenest near the line of junction with the shaft, sometimes very close to the articular cartilage, however, and sometimes in the

periosteum. It presents itself commonly as a single focus, or at times as multiple foci of diseased tissue (encysted tubercle), rarely as a simultaneous tuberculous infiltration of the whole epiphysis (Fig. 2991).

In the formation of single and multiple foci of disease the first change noticeable to the naked eye is the appearance, in an already hyperæmic spot of spongy tissue, of a small, grayish, rather translucent spot, as small as can be seen, perhaps, which grows more gray and increases in size; and around it a zone of hyperæmic tissue develops, and the neighboring bone becomes a little boggy-looking from an excess of fluid transuded. There is no affection of the synovial membrane, it is purely a localized ostitis, or, more correctly, osteomyelitis (Fig. 2992). The area of disease grows larger, and begins to look, in spots, yellowish, and to show a tendency to cheesy degeneration in the centre; and later in the history of the affection nodules will be found, varying in size from a pea to a hazelnut, filled with a putty-like substance, like the cheesy material found elsewhere in the body, except that here it contains spicules of bone from the trabeculæ, and in the larger foci pieces of dead bone of considerable size. Later in the history of the affection the tuberculous nodule ordinarily breaks down into pus. Oftener than not the original focus is surrounded by smaller tubercles which aid in its extension; but the chief work is done, as we shall see, by the erosive action of the granulations. Sometimes a sequestrum of considerable size may be found in these cavities; the granulations have cut off the source of nourishment from a certain area of bone, and it has died and is loosened from the sounder parts, and lies loose in the cheesy or liquid pus; or a piece of bone too large to be contained in the cavity may die and be detached as a wedge-shaped piece at the end of the tibia. Ordinarily these larger pieces are of a wedge shape, with the base at the end of the bone, the ordinary shape of an infarction. Even the whole epiphysis of the femur may be detached (Fig. 2993). The cavity, it should be noted, is lined by pyogenic membrane; at first it is soft and gelatinous, later it becomes more resistant and tougher. If the retrogressive metamorphoses take place, the surrounding tissue takes on a sclerosis, a sort of scar formation.

From this stage of the process any one of three courses is possible: the diseased focus may be absorbed and so

FIG. 2992.—Focus of Disease in Head of Femur.

cured; it may extend to the periphery of the bone and break through the periosteum and empty itself there; or lastly, and probably most commonly, it may extend to the joint and infect that.

In other cases the original invasion of the bone tissue is less focal and more diffused—the epiphysis becomes more pale and later yellow in certain portions which degenerate (Fig. 2994).

Microscopic examination of the contents of the degenerated spots shows a typical tuberculosis.

The tubercles are found in a dense plasma composed of a great quantity of amorphous matter, fatty and calca-

FIG. 2993.—Separation of the Head of the Femur at the Epiphyseal Line.

reous granules, and leucocytes. Outside of this one sees enlarged bone spaces, atrophy of the trabeculæ, fatty-degenerated bone cells, becoming embryonic tissue as one nears the seat of disease. In short, the changes are those which we have seen accompanying long-continued hyperæmia in bone, and which constitute rarefying ostitis.

With regard to the ultimate infection of the joint from the epiphyseal focus, the process is easily understood. The seat of the disease is ordinarily not far from the cartilage when it is beginning, as we have seen; it excites no joint inflammation, but when it reaches a certain stage, even before it breaks into the joint, inflammatory reaction in the joint begins. This is perfectly well established in one of Lannelongue's early autopsies: in a case of early hip disease, a focus the size of a pea was found in the epiphysis, 2 mm. from the cartilage; it was caseous and did not in any way communicate with the joint, yet although there was no effusion the capsule was thickened, the synovial membrane in parts thickened and fungous, and the round ligament already vascular and fungous. The cartilage in certain parts was thinner and losing its elasticity. One other of his autopsies and the early resections of Volkmann show the same point, even more advanced joint changes being found than Lannelongue's autopsies showed, viz., increased synovial fluid, swelling of periarticular structures, and thick and red synovial membrane.

"The danger to the joint begins with the softening of the cheesy masses" (Volkmann). When once the pus has broken through the softened and degenerated cartilage and has reached the synovial membrane, a purulent synovitis is at once started up which speedily assumes a fungous and destructive character, and a "panarthritis" has begun. Thickening of the capsule, infiltration of the periarticular tissues, and thickening of the ends of the bones follow quickly, and abscess formation and all the other complications are ready to follow. It matters little now whether the process began in the synovial membrane or the bone; this stage being the same in its clinical appearances and its capability for evil. Any amount of destruction is of course easily possible—erosion of the articular surfaces, spontaneous subluxations and luxations of the joints, cold abscesses of any extent reaching the surface and continuing to discharge by many sinuses;

Joints.

and, worst of all, from the local disease comes the dissemination of general tuberculosis, or tuberculous meningitis, or phthisis.

Sometimes, however, the focus is so situated that the line of least resistance takes it to another part of the bone surface away from the joint; Volkmann showed clearly that this was no very uncommon occurrence. As it reaches the periosteum the latter thickens and inflames, and, finally softening, allows the pus from the original focus to pass into the periarticular structures, there to form an abscess which must be evacuated externally or break.

There are certain variations of the above condition. *Arborescent tuberculous synovitis* in which the synovial membrane is covered with branching tags consisting of vascular tissue containing tubercles. *Solitary tuberculous nodules* of the synovial membrane, mentioned by Cheyne, Krause, König, and Riedel. Tuberculosis may be shown by *rice bodies*. *Hydrops articulorum tuberculosis* is the name given by König to a condition of chronic effusion, said to be primarily synovial, in which at first there is no marked thickening of the synovial membrane, while later it may present all the characteristics of a typical tuberculous synovitis. *General miliary tuberculosis of bone* may occur in connection with general miliary tuberculosis.

The generalization of tuberculosis from a diseased joint in the hunman subject is a process unfortunately of such common occurrence that it can be passed over very briefly, and it shows even more clearly than experimental inoculation the relationship of tuberculosis and this class of joint diseases. A few figures may show the great liability of this. Billroth found that fifty-four per cent. of patients dying with this form of joint disease die of acute miliary tuberculosis; Jaffé, that fifty-three per cent. of the deaths are from general tuberculous infection. Grosch's extensive statistics show that in hip disease tuberculosis is, in spite of antiseptic precautions, the commonest cause of death. Nor does the removal of the diseased joint seem to diminish this liability very much. König did 117 resections for this class of joint disease, and of 25 deaths he found 18 due to general tuberculosis, and 9 more patients hopelessly tuberculous; and he has called attention to the danger of "operative tuberculous infection," when, by opening the lymphatic and blood channels in an operation which at the same time stirs up the focus of disease, tuberculous material is carried over the body and general tuberculosis results.

Caumont found no preventive effect in resection, for in twenty-six cases of hip disease, treated expectantly, one-

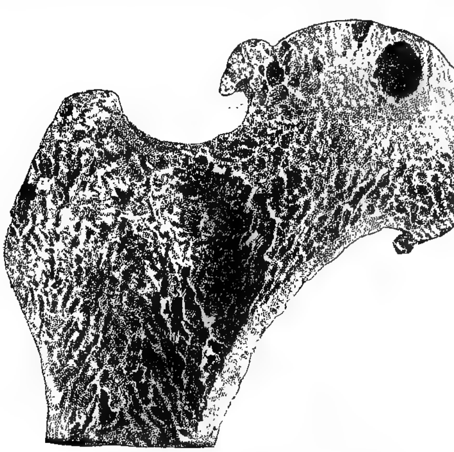


FIG. 2994.—Abscess of the Epiphysis.

fifth died of generalized tuberculosis, while twelve others were resected and one-third died of the same cause.

The frequency with which different joints are affected can be learned only by the consideration of large groups of cases. Schuller gives the following table from 439 cases of Socin and his own: Knee, 35.8; hip, 15.9; elbow, 12.7; tarsus, 11.8; foot, 9.6; hand, 6.2; shoulder, 4.1 per cent., etc.

Billroth and Menzel in 1,996 cases found the distribution as follows: Vertebral column, 35.2; knee, 11.9; head bones, 10.2; hip, 9.4; sternum, clavicle, ribs, 9.2; ankle and foot, 7.5 per cent.

Gibney, in 614 cases, mostly in children, found 209 cases of spinal disease; 271 cases of hip disease; 103 cases of knee disease; 31 cases of ankle disease.

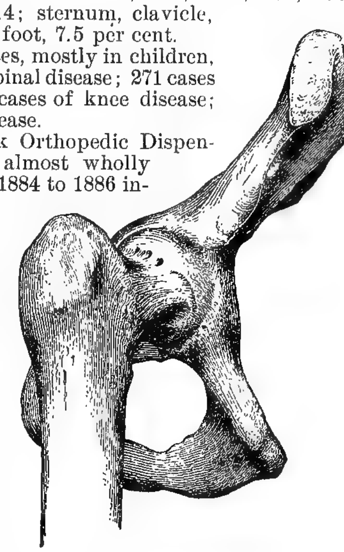


FIG. 2995.—Ankylosis of Hip.

At the New York Orthopedic Dispensary, dealing also almost wholly with children, from 1884 to 1886 inclusive, there were observed: 2,644 cases of chronic joint disease of this type, in which there were 1,178 cases of hip disease; 1,024 of vertebral disease; 83 of ankle disease; 319 of knee-joint disease; 7 of wrist disease; 11 of elbow disease; 11 of shoulder-joint disease; 11 of multiple joint disease.

At the Children's Hospital, Boston, in the years 1890–1898 inclusive, there were treated in the wards and out-patient department 3,018 cases of chronic tuberculous joint disease. The distribution was as follows: Hip, 1,284; vertebræ, 1,169; knee, 380; ankle, 119; elbow, 28; shoulder, 14; phalanges, 10; wrist, 10; sacro-iliac, 4.

Age. Tuberculous joint disease is pre-eminently a disease of childhood. It is rarely, if ever, congenital, and under one year it is not common. Of Gibney's 860 cases, already alluded to, 84.5 per cent. of all cases occurred before fourteen. Of 619 cases of hip disease tabulated by Wright, there were:

Under 6 years	40 cases.
From 6 to 10 years	110 "
" 10 to 15 "	129 "
" 15 to 20 "	66 "
" 20 to 25 "	39 "
" 25 to 30 "	17 "
" 30 to 35 "	9 "
" 35 to 40 "	4 "
" 40 to 50 "	3 "
" 54 to — "	1 case.
Total	418 cases.
Two years and under	28 cases.
From 2 to 5 years	62 "
" 5 to 10 "	81 "
" 10 to 14 "	30 "
Total	201 "

Mr. Bryant has tabulated 360 cases as follows:

Under 4 years	126 cases.
From 5 to 10 years	97 "
" 11 to 20 "	86 "
" 21 to 30 "	27 "
" 31 to 40 "	13 "
Above 40 years	11 "
Total	360 "

Taking Mr. Wright's and Mr. Bryant's cases, and adding 365 others reported by Dr. Sayre, we have 1,344 cases of hip disease, of which 1,000 occurred under fifteen years of age. This is perfectly natural, for the tuberculous diseases affect the growing epiphysis or the epiphyseal junction during the period of activity, and tuberculosis of all sorts is common in childhood.

The records of the New York Orthopedic Dispensary show the liability at different ages in the cases of joint diseases of the leg treated for the years 1884–1886:

	Under 3.	3–5.	5–10.	10–15.	15–20.	Over 20.
Hip	115	316	509	140	47	51
Knee	43	69	94	28	22	63
Ankle	12	18	24	18	4	7
	170	403	627	186	73	121

The liability of the aged to tuberculous joint disease must, however, not be overlooked. The fact that people over sixty are more often "scrofulous" than people between thirty and fifty, was noted by Sir James Paget. The patients may be seventy-five or ninety, and cases of hip disease present the same pathological appearances here as in young children. The course of the disease is naturally more rapid and destructive than in the young.

Infectious Osteomyelitis.—Infectious osteomyelitis sometimes affects the epiphyses of the long bones, and in that way secondarily infects the joints. It begins in the bone marrow or the periosteum. The marrow becomes hyperæmic, the periosteum infiltrated and thickened; then in both are seen beginning foci of pus, and sometimes hemorrhages in their tissue; soon pus formation obscures everything, and the bone fairly melts away; large collections of pus may form between bone and periosteum. Ordinarily this affects the shafts of bones, but sometimes the epiphysis, and secondarily the joint, become infected when the foci of disease are near the joint; like the tuberculous foci, they tend to infect it.

Of bacteria the staphylococcus and streptococcus are most commonly seen, although pneumonia, typhoid, and colon bacilli have been found. There are cases in which infection occurs, but absorption takes place before the occurrence of suppuration; thrombosis of the veins of the bone marrow or metastatic abscesses may occur. If the epiphyseal cartilages are attacked, especially in young children, separation of the epiphyses may take place. The clinical symptoms are those of a severe constitutional disturbance attended by high fever, chills, severe pain, and rapid exhaustion. If the joints are involved there may result ankylosis, subluxations, and distortions.

It is probable that many, if not most of the cases described as the "*Acute Arthritis of Infants*" belong pathologically in this divistion. Of 71 cases of this condition

FIG. 2996.—Acute Arthritis of the Knee.

analyzed by Townsend, 20 were less than four weeks old, 10 were less than eight weeks, and 6 were in their third month (Fig. 2996).

Tumors which affect the ends of the bone may involve and impair the joints. They include those of connective-tissue type, fibrous, mucoid, cartilaginous, osseous, sarcoma, osteo-sarcoma, carcinoma, angioma, hæmatoma, echinococcus cyst, and aneurism. Exostoses, when they occur, impede the motion of the joints; chondromata are also seen. Myxomata and lipomata are rare. Joint sarcomata affect chiefly young subjects from fifteen to twenty or twenty-five years of age. The joints commonly affected are the knee, the shoulder, and the wrist.

III. MISCELLANEOUS.—Certain constitutional affections are attended by joint manifestations. The principal ones are as follows:

(*a*) Syphilis.
(*b*) Arthritis deformans.
(*c*) Rheumatism.
(*d*) Gout.
(*e*) Acute infectious diseases.
(*f*) Gonorrhœa.
(*g*) Pathological conditions of the nervous system.
(*h*) Hæmophilia, scurvy, etc.
(*i*) Functional affections of the joints.
(*j*) Inflammation of bursæ.

(*a*) *Syphilis.*—Joint inflammations in syphilis occur at three stages of the disease: (1) in the early secondary stage; (2) in the tertiary stage; (3) in hereditary syphilis. Each of these forms must be mentioned separately.

(1) Coincident with the early general manifestation of the disease there is occasionally, though not commonly, noted a simple serous synovitis. This condition may pass on to a chronic hydrops.

(2) In the tertiary stage a chronic serous synovitis may be present, accompanied by capsular thickening and a tendency to contraction and fibrous ankylosis. This may be due to the development of gummata in the perisynovial tissues, with chronic hyperplastic synovitis, and later, cartilage destruction. And secondly, the development of gummata in the bone and a secondary affection of the joint.

(3) Hereditary syphilis is more often attended by bone complications than are the other forms. Chronic serous synovitis, sometimes due to bone lesions, occurs. The type described by Clutton occurs in children from eight to fifteen as a symmetrical swelling of the knees accompanied by considerable thickening but little effusion.

The osteochondritis of Parrot is the most characteristic manifestation of hereditary syphilis. Thickening of the cartilage of the epiphysis occurs with irregularity in the zone of ossification; separation of the epiphysis may occur as the result of this as well as of chronic synovitis, sometimes purulent. This condition may be found in dead-born syphilitic children. The clinical manifestations are thickening of the bone with tenderness and lameness. The condition is sometimes spoken of as the "syphilitic pseudo-paralysis" of infants. Late hereditary syphilis may show a thickened and deformed joint the result of a similar epiphyseal affection spoken of sometimes as "false tumor albus." Here whatever joint inflammation exists is secondary and not characteristic.

(*b*) *Arthritis Deformans.*—A chronic affection of the joints occurs in connection with this disease. The reader is referred to the article on *Arthritis Deformans.*

(*c*) *Rheumatism.*—The affections of the joints are either monarticular or polyarticular. The condition occurs in youths and in middle-aged people; it is infrequent in infancy but it may occur. In infants scurvy closely simulates rheumatism. The synovial membrane of the joints in rheumatism is chiefly attacked, it secretes much fluid, and there is enlargement of the presynovial tufts giving rise to a swelling of the joint without necessarily the presence of much effusion. The capsule becomes thickened and the cartilage is likely to remain intact, although it may show signs of chronic inflammation. The whole tendency is toward connective-tissue formation. The clinical symptoms are pain, enlarged joint, swelling, and stiffness. Antirheumatic treatment has a beneficial effect on the condition.

(*d*) *Gout.*—The joint affection in this disease usually begins as an acute attack and is followed by a chronic inflammatory process increased by constant exacerbations.

The joint affection is dependent upon the constitutional disease. The synovial membrane presents first the appearance of acute inflammation, later that of permanent thickening; the cartilage also shows this tendency, and in the capsule of the joint and periarticular structures there appear localized deposits of urate-of-soda crystals, "tophi." There is little tendency to suppuration. The commonest seat is the metatarso-phalangeal joint of the great toe, then the hands, knee, and elbow. The affected joints are enlarged, reddened, stiff, and painful.

(*e*) *Joint Complications in Acute Infectious Diseases.*—The acute infectious diseases in which joint complications occur are as follows: measles, scarlet fever, smallpox, typhus fever, typhoid fever, cerebro-spinal meningitis, pneumonia, dysentery, diphtheria, erysipelas, epidemic parotitis, pertussis, puerperal fever, pyæmia, septicæmia, after the use of catheters and sounds, and possibly in malaria.

The lesions are now almost universally attributed to the presence in the joints of micro-organisms of infectious character. Micro-organisms are found in the diseased joints. It seems as if the question of whether the synovitis were to be a mild serous one, or a violent destructive purulent form, was determined by the kind of micro-organism that reaches the joint, rather than by the especial infectious disease which may be present. In serous effusions one finds the organisms which characterize the especial disease present, and in greater or less number different forms of pyogenic cocci; whereas in purulent and phlegmonous processes one finds exclusively such organisms as staphylococcus and streptococcus pyogenes in enormous numbers. It is suggested that the synovitis of rheumatism is of the same character, but no evidence in support of the theory has been adduced. The affection may be serous or purulent, mild or severe. It must be mentioned that certain cases of joint tuberculosis seem to have their origin after the acute exanthemata.

(*f*) *Gonorrhœa.*—Inflammation of the joints may occur in the later stages of gonorrhœa and is commoner in men than in women. The condition may be acute or chronic and most often is polyarticular. There may be effusion which, if serous, is thick and may contain clots of fibrin, or it may be sero-purulent or colored with blood, and the gonococcus has been demonstrated in the joints, although it may be absent. The commonest types of inflammation are arthralgia, acute and chronic synovitis, periarticular inflammation, with joint effusion absent or subordinate, and tenosynovitis about the joints. Impairment of motion and ankylosis are liable to result, and the affection is always slow in progress, resistant to medication, and serious. The treatment consists of rest by fixation, counter-irritation, hot-air baths, and massage. If the condition proves obstinate, incision and irrigation of the joint are indicated and suppuration demands incision.

(*g*) *Pathological Conditions of the Nervous System.*—A destructive form of joint disease may be associated with tabes dorsalis, syringomyelia, acute myelitis, cerebral apoplexy, injury of a peripheral nerve, tumors of the cord, crushing of the cord, progressive muscular atrophy, and anterior poliomyelitis. These affections are called Charcot's disease, spinal or neuropathic arthropathy, neural arthropathy, etc. (Fig. 2997). The condition is most often monarticular and usually attacks adults, although patients as young as six years have been reported. The pathology is much like that of arthritis deformans, only the destructive process is more active and the formative one less so. The essential character of the condition is the rapid melting away of cartilage and bones. Swelling, effusion, disability, and sometimes pain are the first symptoms; spontaneous arrest may occur, ankylosis rarely results, and the joint may be disorganized to the point of luxation. Excision in some cases affords relief, but the treatment must be expectant and protective.

(*h*) *Hæmophilia and Other Conditions.*—Hæmophilia is at times characterized by characteristic joint lesions clinically resembling tuberculosis in their general appearance. After repeated acute attacks of hemorrhage into the joint, chronic changes are likely to ensue, which consist of synovial proliferation, degeneration of cartilage, and erosion

FIG. 2997.—Charcot's Disease. (Weigel.)

of the ends of the bones in severe cases with a proliferation at their edges not unlike arthritis deformans.

Pain, swelling, and muscular spasm are the clinical manifestations.

The treatment consists of protection and fixation during the acute stages.

Scurvy.—In scurvy the joint condition simulates closely epiphysitis and rheumatism, especially in young children. There is thickening of bone due to subperiosteal hemorrhage, and the condition responds readily to antiscorbutic treatment.

Pulmonary Hypertrophic Osteo-arthropathies represent a condition which is manifested by clubbing of the fingers and by stiffened, thickened shafts of bones. The spine is bent forward in kyphosis. The relation to acromegaly and osteomalacia is not clear. The joints are swollen and painful, and there may be synovitis and periostitis.

(*i*) *Functional Affections of the Joints.*—Under the names of hysterical joints, joint neurosis, neuromimesis, etc., is described a condition characterized by pain and often disability for which no objective cause can be found in the joint. The affection resembles in many of its aspects organic joint disease, but it has no pathological basis. It affects most often young women, and sometimes children, and simulates at times rather closely in its symptoms the symptoms accompanying real disease of the same joint.

The diagnosis has to be made with much care. The muscular spasm varies, and is partly voluntary, atrophy is less, joint effusion is not present, and the diagnosis has to be based on a lack of correspondence between the severe subjective symptoms—pain, tenderness, sensitiveness—and the absence of evidence of organic changes—inflammatory destruction of bone, characteristic distortion,

etc. There is a lack of harmony between the symptoms presented and those found at any one stage of the usual joint affections. The limp is greater than would be

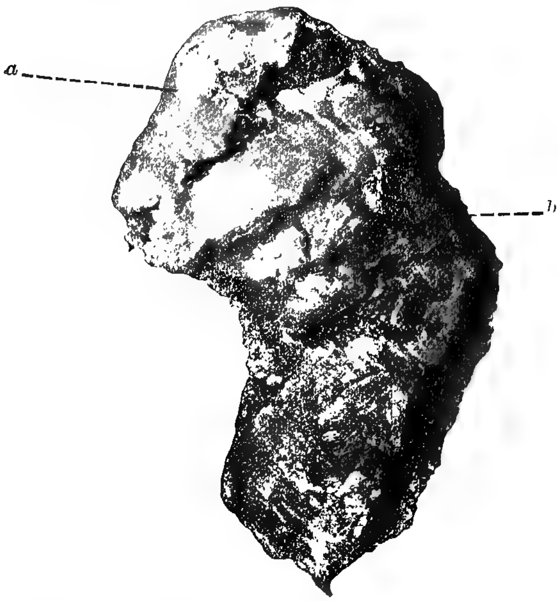


FIG. 2998.—Hip Disease. Process extending from primary focus in acetabulum along round ligament. *a*, Head of femur covered with elevated cartilage; *b*, neck. (Nichols.)

found with the amount of unconscious active motion at the joint. The pain and tenderness are more severe than is usual at an early stage of the affection, unless uncommonly rapid, and accompanied by marked swelling of the joint.

There may be some periarticular swelling and occasional redness. These are, however, usually slight, and due to vaso-motor disturbances rather than to true inflammation. There is but little or no muscular atrophy in functional affection of the joint; this condition being always present in true chronic diseases of the joint. There is no diminished muscular contraction to faradic irritation, as is the rule in organic disease of the joint. The pain, when present, is not so severe at night as in the acute stages of true joint affection.

The treatment consists in insisting on the progressively increasing use of the leg after the diagnosis has been made. Measures to stimulate the local circulation are of use.

(*j*) *Inflammation of Bursæ.*—The inflammation of bursæ from wounds, bruises, or constitutional causes may lead to the secondary inflammation of the joints with which they happen to connect. For example, the large bursa between the neck of the glenoid process and the subscapular muscle is ordinarily in connection with the shoulder-joint, as is the case more rarely with the bursa under the deltoid. The bursa beneath the triceps tendon is oftenest a prolongation of the elbow synovial membrane. The bursa under the psoas and iliacus tendon frequently communicates with the hip-joint, and the bursa in the popliteal space often communicates with the knee-joint. These are the common paths of communication, but as a matter of fact joint disease is rarely caused in this way.

Lipomata may occur in the joints beneath the synovial membranes, often causing chronic synovitis. The joints may be inflamed secondarily to periarticular abscess. Growing pains of children may give symptoms referred to the joints. Other conditions causing impairment of joints are cicatrices after burns, wasting of muscles and ligaments in infantile paralysis, muscular contractions causing malpositions, and fractures involving the joints.

DISEASES OF THE HIP-JOINT.—I. *Tuberculous Ostitis* (hip disease, morbus coxarius, morbus coxæ, coxalgia, coxitis, chronic ostitis of hip, coxo-tuberculosis, etc.) is a chronic tuberculous ostitis of the epiphysis of the head of the femur or of the acetabulum (Fig. 2998). When the acetabulum is affected primarily or secondarily, enlargement of the cavity upward occurs, because as the pelvic muscles contract they crowd the head of the femur against the upper and back part of the acetabulum. This causes shortening of the limb and the trochanter rises above Nélaton's line. In the same way, the head of the femur becoming softened and destroyed, as a result fo the persistent muscular spasm, the limb may be shortened; a second cause of shortening is to be found in the retarded growth of the limb. True dislocation of the hip in ordinary tuberculous ostitis rarely occurs. The same is true of epiphyseal separation, although subluxation is seen at times,—especially when traction has not been used. Fracture of the atrophied and degenerated neck or shaft of the femur may rarely occur. In the typical case there is seen a thickened, reddened synovial membrane, with the cartilage hanging or eroded, giving a worm-eaten appearance. The epiphyseal portion has disappeared wholly or in part, and a ragged, softened end of bone articulates with an acetabulum covered with fungous granulations in part or wholly replacing cartilage. The whole epiphysis may form one sequestrum, although this is not common, and perforation of the floor of the acetabulum may take place, resulting in suppuration inside the pelvis, with the formation of an abscess. Abscess will, as well, appear externally, if the disease extends into the periarticular tissues or if a separate focus forms outside the joint and spreads to surrounding soft parts. A natural cure of hip disease may occur by absorption or calcification of the diseased focus at an early or late stage, or by the purulent degeneration of such tissue, discharging and evacuating externally. Ankylosis, shortening of the limb, and much impairment of the general health are the natural results of these conditions (Fig. 2999).

The beginning of the affection is usually gradual. The

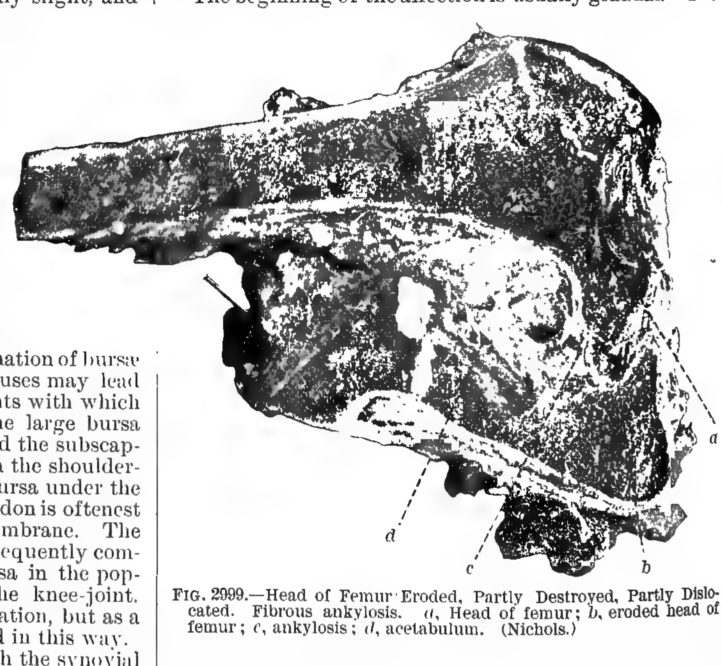


FIG. 2999.—Head of Femur Eroded, Partly Destroyed, Partly Dislocated. Fibrous ankylosis. *a*, Head of femur; *b*, eroded head of femur; *c*, ankylosis; *d*, acetabulum. (Nichols.)

child will be noticed to limp at times. This lameness increases, and it will be found that the patient is inclined to strike the ball of the foot rather than the heel in walking; although the heel can be put down to the floor, yet

instinctively the knee is slightly bent and the heel raised when the weight of the trunk falls on the hip. There is a certain amount of stiffness of gait apparent in the morning when the patient first gets out of bed, and after sitting for a while; this passes away after the patient has walked or played about. The symptoms may at first be unaccompanied by pain, but later there is an occasional complaint of pain in the knee. If the child be inspected it will be seen that, although able to run about and play freely, there is a noticeable limp, and in standing the knee of the affected side is usually flexed slightly, the pelvis being tipped, the thigh slightly abducted (Fig. 3000); the tilting of the pelvis and abduction of the thigh may be so slight that it is scarcely noticeable, except by the deviation from the median line of the fold between the two buttocks. In girls the vulva on the affected side will be seen to be lower than on the other side.

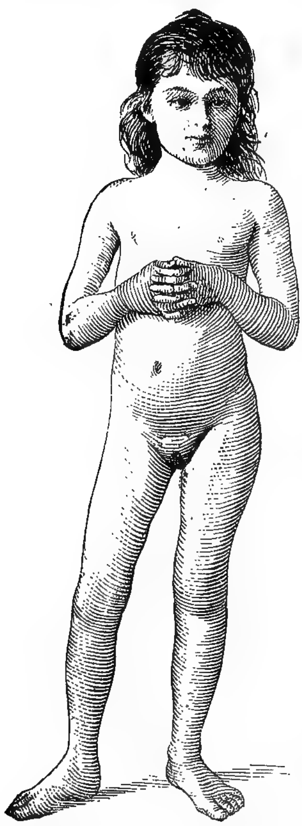


FIG. 3000. — Position Assumed in Standing, the Right Leg being Slightly Abducted.

Limping. The symptoms gradually increasing, viz., limp in gait, stiffness, and slight pain, the patient may find difficulty in walking, and complain of rheumatism or "growing pains," which will pass away under friction or domestic remedies and rest, again appearing at irregular intervals.

The limb at this time will be found somewhat smaller in the circumference of the thigh than the other; there will be marked limitation of the usual free motion at the hip-joint, the pelvis moving on motion of the thigh, or moving on motion of the thigh beyond a limited arc.

Pain. As the affection progresses, pain in the knee and sensitiveness to jarring the limb may become a prominent symptom—the pain being almost invariably located by the patient in the knee. The adductor muscles of the thigh will be found near the symphysis pubis to be prominent and contracted, and frequently there is a thickening of the tensor vaginæ femoris noticeable on palpation, as well as an apparent broadening of the trochanter of the femur. An unconscious protection of the joint will be noticed in the movement of the patient—the foot of the well limb will be placed under the lower part of the leg when it is to be suddenly lifted by the patient, as from the floor to the bed, or from the bed to the floor, or in moving from one side of the bed to the other. In walking, the patient instinctively avoids resting weight upon the limb, except for as short a time and with as little jar as is possible, the thigh being slightly flexed, the knee being bent, and the heel raised so that the shock upon the acetabulum from pressure of the head of the femur, when the weight of the body is thrown upon the limb, may be broken at the knee- and ankle-joints, which serve as springs. This attitude of the limb—flexion of the thigh—becomes habitual and characteristic; to it are added, in the earlier and acuter stages, abduction and outward rotation of the limb.

It should be always borne in mind that tenderness or sensitiveness at or about the joint may be absent, and the absence of these symptoms does not indicate the absence of well-pronounced disease. The joint may be firmly held by muscular spasm, allowing restricted motion on manipulation, while sensitiveness may be absent.

A sensitive condition of the joint, however, may supervene.

Night Cries. At this stage of the affection the symptom of "night cries" often appears. They occur in the early part of the night, usually, and may become an exceedingly annoying symptom. After the patient is asleep, and entirely unconscious to all appearance, sleep will be interrupted by a loud cry as if of severe pain, followed by moaning or crying for a few seconds; the patient being unconscious or only half-conscious of the cause of the pain. These do not occur when the patient is entirely awake, and are caused by the spasmodic twitching of the muscles abnormally irritable from irritation reflex to the inflammation of the joint. These cries may vary from a short moan to a piercing shriek, and may in the severest cases be repeated fifteen or twenty times during the night. They do not occur in the later stages of the disease, and may be entirely wanting in the mildest cases. They resemble somewhat the cry in the "night terrors" of nervous children, but differ from that in that there is greater evidence of extreme pain, and no connection with unpleasant dreams, apprehension, or fright. From the testimony of patients old enough to explain symptoms, the pain is reported to be extremely sharp and severe, suddenly interrupting sleep and awakening the patient, and leaving an ill-defined sense of an aching in the thigh and hip.

The sensitiveness of the joint may become great, and an acute stage supervene during which the slightest movement of the patient, or jar of the bed or room, causes extreme suffering. The limb is flexed at the thigh, everted and abducted or adducted (Fig. 3001). This stage may come suddenly and then gradually pass away, the pain diminishing slowly under the enforced treatment of rest, but it may be prolonged for months. The patient will by degrees become able to move the limb, or to steady the limb with the sound limb or with the hands. Characteristic is a position frequently taken by the patient, who places the well foot on the dorsum of the foot of the affected limb, exerting pressure away from the acetabulum.

Neither adduction nor abduction of the diseased limb is characteristic of the disease from the first; they may persist throughout the whole affection. Abduction may not be present, and adduction may not appear until late in the disease.

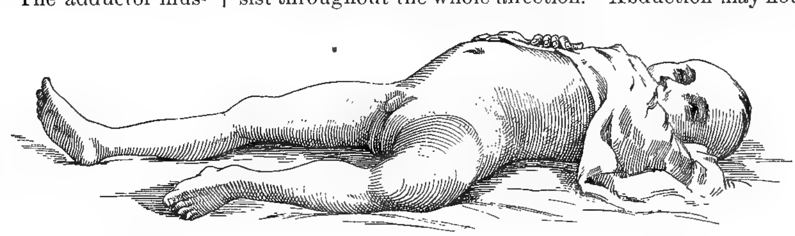


FIG. 3001.—Severe Abduction and Eversion in a Very Acute Case.

Atrophy. A marked atrophy of the muscles of the thigh and of the glutæi is characteristic. It is supposed to be reflex to the disease of the joint, and if the muscles of the thigh are tested for contractility to the irritation of the faradic current, it will be found that the contractility

is markedly diminished. The upper part of the thigh and the tissues in the vicinity of the hip may become swollen, particularly the lymphatic glands of the groin

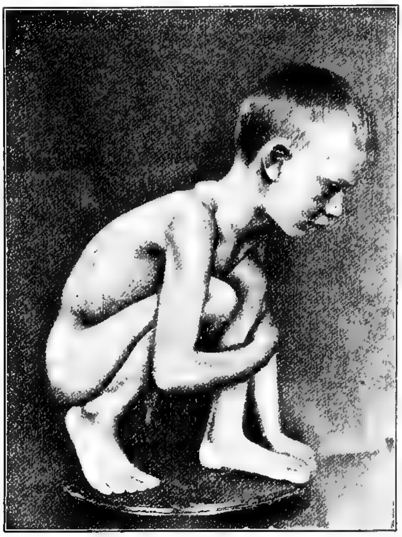


FIG. 3002.—Progression in a Case of Severe Double Hip Disease.

and in the iliac fossa—an œdema of the periarticular tissues taking place, similar to that seen in the knee in the so-called "tumor albus"; this may disappear or become localized in the formation of an abscess.

Distortion of the Limb.—Flexion of the thigh is a symptom which, noticeable even in the early stage of the disease, may become marked as the disease progresses. It was originally supposed to be due to an effusion in the capsule of the hip-joint, but it is seen together with adduction and abduction in cases in which no effusion has taken place. It is chiefly due to the muscular contraction which is constant in chronic disease of the joint, and partly to an unconscious effort on the part of the patient to assume a position most comfortable for the joint and most protected from jar. In double hip disease flexion may produce a severe deformity. The attitude of flexion and adduction is characteristic of the last stage of the disease (Fig. 3003).

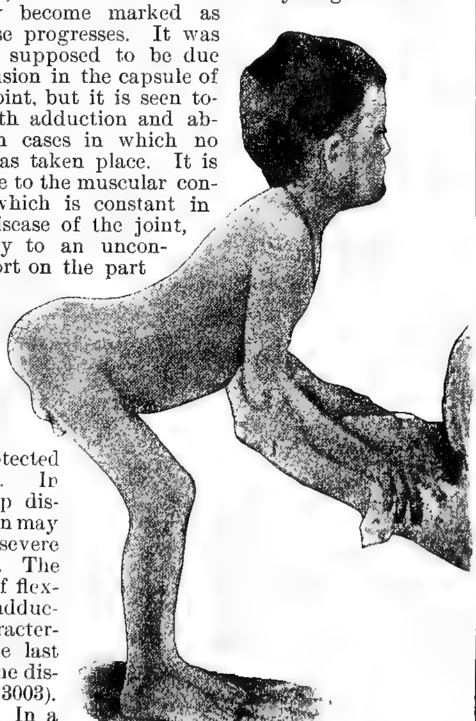


FIG. 3003.—Flexion in Double Hip Disease. (From a photograph.)

Abscess. In a certain proportion of cases suppuration takes place; in the severer forms, accompanied by much pain or by severe pain for a long period, suppuration is the rule. The site and course of the abscesses vary according to the seat and size of the original focus of the ostitis. Abscesses may be entirely periarticular, if the initial lesion of the epiphysis extend in a course outside of the joint; or they may come from suppuration within the joint; or, having been periarticular, they may later involve the joint (Fig. 3004).

The invasion of the abscess is often unaccompanied by constitutional disturbance, as is not infrequently the case in cold abscesses in general, and leucocytosis is not characteristic. In cases of hip disease there is a slight fever, but it does not necessarily indicate the presence of abscess. This condition may not interfere with a fair appetite and more or less satisfactory general health, but as a rule the appetite is capricious.

Abscesses may be absorbed spontaneously or may discharge themselves. They may almost completly evacuate themselves, and the residual fluid, following along the

FIG. 3004.—Hip Abscess with Deep Fluctuation at Anterior and Upper Part of Thigh. (Fiske Prize Fund.)

course of the sheaths of the muscles and the fasciæ, reappears later as a second abscess; in some cases the same abscess may even cause five or six fistulous openings.

Prognosis.—Hip disease is a self-limited disease. A natural cure takes place in a majority of cases, but the cycle of invasion, efflorescence, convalescence, and cure, always consumes a long period of time. The natural cure in the lightest cases leaves a limitation of motion in the hip. This is accompanied by a limp. In severer cases there is practical stiffness at the joint, with fibrous or eventual bony ankylosis at the hip-joint, flexion and adduction of the limb, with shortening. Subluxation of the femur with shortening of the limb is a common result of the natural cure, and an arrest of growth with actual shortening of the bone.

The sinuses of abscesses may close in time after the separation of sequestra; and in some instances a large sequestrum, constituting nearly the whole head of the femur, has been spontaneously evacuated, giving a useful limb.

Death in the course of hip disease takes place not infrequently from tuberculous meningitis. Death may also be caused by exhaustion and the septic involvement or amyloid degeneration of various organs (liver, kidney, etc.) secondary to suppuration and sinuses.

It is important, in an examination for hip disease, to determine the amount of permanent injury which the disease has already inflicted. The amount of enlargement of the acetabulum and absorption of the head of the femur which has taken place, may be estimated by determining the amount of subluxation. If the patient lie upon the well side, and a line be drawn over the suspected hip (the thigh being somewhat flexed) from the anterior superior spine to the most prominent part of the tuberosity of the ischium, it should pass just above the upper margin of the trochanter; if the trochanter is above this line, it is an evidence of subluxation.

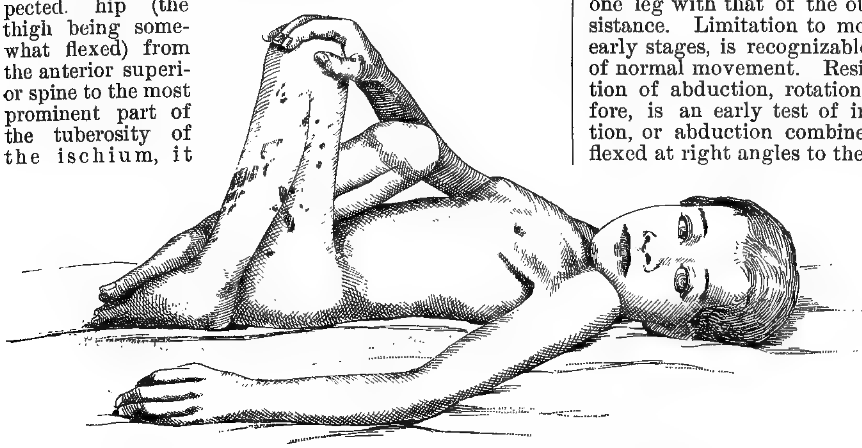


FIG. 3005.—Deformity in Untreated Double Hip Disease.

In focal disease of the hip-joint, if the focus of osseous inflammation is situated in such a part of the epiphysis of the femur that, when extension is made, it evacuates itself into the periarticular tissue, rather than into the joint; or if the osseous inflammation is not rapid in its progress, and is well limited by a surrounding ossifying cicatricial ostitis, the symptom of pain or sensitiveness will be absent for a long time, if present at all.

But certain features are common to all these different types, viz., the aspect of the limb, the peculiarity of attitude (flexion, abduction, and adduction), and the limitation of motion at the hip-joint.

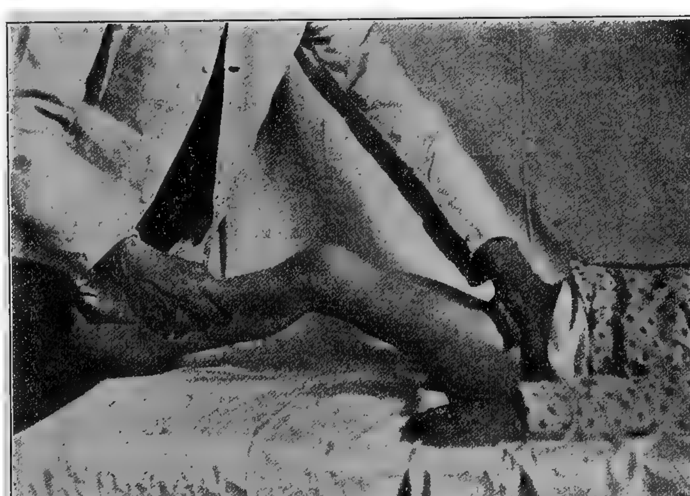


FIG. 3006.—Method of Examining Hip.

There is a certain amount of variation in the degree of deformity left in the natural cure of hip disease, depending upon the severity of the disease and the amount of body distortion. The flexion and adduction may be so slight as to cause only a little shortening, or they may be sufficient to impair the usefulness of the limb. A most distressing deformity follows the natural cure of double hip disease. This may leave severe flexion of both femora, or flexion and adduction so that the limbs are crossed (Fig. 3005).

Diagnosis.—The diagnosis of hip disease is ordinarily not difficult; in the earliest stages, however, errors in diagnosis are sometimes made, and great care is necessary if we wish to avoid them. The most common error is the belief that pain and tenderness are necessarily present in all cases of hip disease, and that their absence excludes the possibility of hip disease. Pain and tenderness are not, however, early symptoms in a majority of cases.

Lameness. A limp in gait is an early symptom, in fact the earliest symptom. It may be said that no hip disease can be present without giving rise to a limp in gait. At the earliest stages, however, the limping may be intermittent and not constant. The same may be said of a limitation of motion at the hip-joint.

Muscular Stiffness. It should be borne in mind that some care is required to discover slight limitation of motion in very young children, who are apt to resist thorough examination. The resistance to motion due to fright is, however, always resistance to any motion of the limb; if by slight force this is overcome, resistance to rotation of a flexed thigh, or to extreme flexion, will not be encountered. A comparison of the resistance of one leg with that of the other will reveal abnormal resistance. Limitation to motion at the hip-joint, in the early stages, is recognizable at the extremity of the arc of normal movement. Resistance to motion in the direction of abduction, rotation, and hyperextension, therefore, is an early test of importance. Extreme abduction, or abduction combined with rotation of the thigh flexed at right angles to the body, is also a delicate test.

In young and frightened children, the tests for limitation of motion at the hip-joint are best made with the child lying on the mother's lap, or leaning on the mother's shoulder; but ordinarily the best position is with the patient lying upon a hard flat surface.

A limitation to flexion is determined by flexion of the normal limb on the abdomen to its utmost limit, and afterward by a repetition of the motion of the suspected limb. If the limb is then extended so that the popliteal space comes in contact with the hard surface on which the patient lies, there will normally be no alteration of the position of the back; if, however, there is a diminution of the normal extension of the limb, the back will be arched up as the popliteal space is pressed down.

This limitation to extension can also be determined by examining the patient lying upon the belly. If one hand be placed on the sacrum and the thighs be alternately raised from the surface on which the patient lies, a difference in the amount of motion at the hip without moving the sacrum can easily be determined. The degree to which abduction or adduction is diminished is determined by placing one hand on the anterior superior spine of the ilium on the sound side, and with the other hand gently abducting or adducting the suspected limb.

Careful inspection in the early stages of hip disease will sometimes show fibrillary contraction of the muscles

of the thigh on sudden or unexpected movement of the limb.

In the later stages of hip disease the joint becomes practically ankylosed, there being no motion at the hip-joint. This is due to muscular spasm and disappears under complete anæsthesia, unless a permanent degeneration of the muscle has taken place, or a fibrous ankylosis of the hip-joint has begun to be developed.

A limitation to rotation at the hip is not so readily detected in the earliest stages of hip disease. Often the foot can be turned in and out with apparently normal freedom; if, however, the thigh be flexed upon the abdomen, and an attempt be made to rotate the femur and at the same time abduct it, at a very early stage unusual resistance to this motion will be found on the affected side as compared to the normal side.

In examining an older person for muscular stiffness, the clothes should be removed and the patient should lie upon a hard surface. Attempts to move the limb should be made gradually and gently and persistently,—rough force only exciting resistance and making a delicate examination impossible. The most convenient order of executing these different movements is, first, flexion, then abduction and abducting rotation with the thigh flexed, then extension. The suspected limb should be held at the ankle or knee (Fig. 3006).

Attitude. The peculiarity of the patient's attitude in standing or lying in bed—the flexion, abduction, or ad-

FIG. 3007.—Severe Hip Disease, with Adduction.

duction of the limb—in marked cases of hip disease is most important (Fig. 3008). In the earlier stages this can usually be noticed on careful watching, and the peculiar care with which the patient moves and steadies the limb, as compared with the sound limb, in getting in and out of bed, is of diagnostic importance.

The abduction of the limb is usually not recognized by the patient as abduction, but the complaint is made that

FIG. 3008.—Early Hip Disease of Right Leg, showing Abduction.

the limb seems longer than the other. The pelvis is tilted, which gives a practical lengthening of the limb. In the same way the limb appears shorter to the patient if adducted. The tilting of the pelvis can be recognized by drawing a line from the anterior superior spine of one side to that of the other. This should be at right angles with a line from the umbilicus to the symphysis pubis.

Atrophy. Atrophy of the muscles is an early symptom, and is determined by measuring the circumference of the thigh and calf.

The obliteration of the fold of the buttock mentioned in the older writers is due to this atrophy, but it is not always one of the earliest symptoms.

The muscular atrophy of hip-joint disease differs from that of infantile paralysis in that it is not as great, and that the power of the muscle is not lost. The muscular atrophy is greater, as a rule, than that of simple disuse of the muscles.

In the earliest cases the atrophy may be so slight as to escape detection by the tape measure.

Pain. The pain in well-marked hip disease is almost invariably located at the knee; pain located at the hip is exceptional.

The resort to violent jarring of the hip is unnecessary in the examination of a patient for hip disease.

Swelling. In an early stage of hip disease there is, as a rule, no swelling, unless the affection is advancing at an unusually rapid rate.

Joints.

An apparent condensation or thickening of the deep and the superficial tissues, to be felt on palpation, usually can be found in hip disease at a comparatively early stage. *X*-ray examination is a help in the diagnosis. In the earlier stages little is to be seen, but later a cloudiness and obscurity in outline may be detected, and this is followed by a disappearance of part of the epiphysis as destruction progresses.


FIG. 3009.—Flexion in Hip Disease. (From a photograph.)

To recapitulate the symptoms on which a diagnosis of hip disease is based, they may be summed up as follows: (1) Limping; (2) limitation of motion or stiffness of the joint in certain directions of normal motion; (3) peculiarity of attitude or distortion of the limb; (4) muscular atrophy; (5) pain or sensitiveness; (6) thickening about the trochanter; (7) appearances shown in the radiograph.

Differential Diagnosis.—A list of the diseases which have been mistaken for hip disease would be a long one. Sarcoma of the hip may at first be mistaken for hip disease.

A differential diagnosis between synovitis of the hip-joint and chronic epiphyseal ostitis is not possible at an early stage in the disease, and is not necessary, as the treatment is the same, though the prognosis of chronic synovitis may be somewhat better.

Periarticular disease, which has not yet attacked the joint or the epiphyses of the joint, is recognized by the fact that the inflammation invading certain groups of muscles causes a limitation to motion greater in one direction than in another, while the limitation to motion in disease of the joint is equal in all directions of normal motion of the joint.

Under the head of periarticular disease may be included inflammation of bursæ, or of lymphatic glands, or psoas abscess, or psoas muscular spasm from Pott's disease. This latter disease is not infrequently mistaken for hip disease. A careful examination of the muscular spasm aids the diagnosis. The bursa under the ilio-psoas muscle may become inflamed and the seat of abscess-formation. It may be primary, or secondary to disease of the hip-joint. (Lund, in *Boston Med. and Surg. Journal*, 1902.) The diagnosis between true and neuromimetic affections of the hip is at times difficult. In a functional (hysterical) trouble there are a predominance of subjective symptoms of pain, sensitiveness, etc., and an absence or relative insignificance of the objective symptoms of muscular atrophy, characteristic attitude, and distortion. The stiffness on passive motion of the hip is much greater than would be usual in an early stage of hip disease, and out of proportion to the amount of unconscious active voluntary motion.

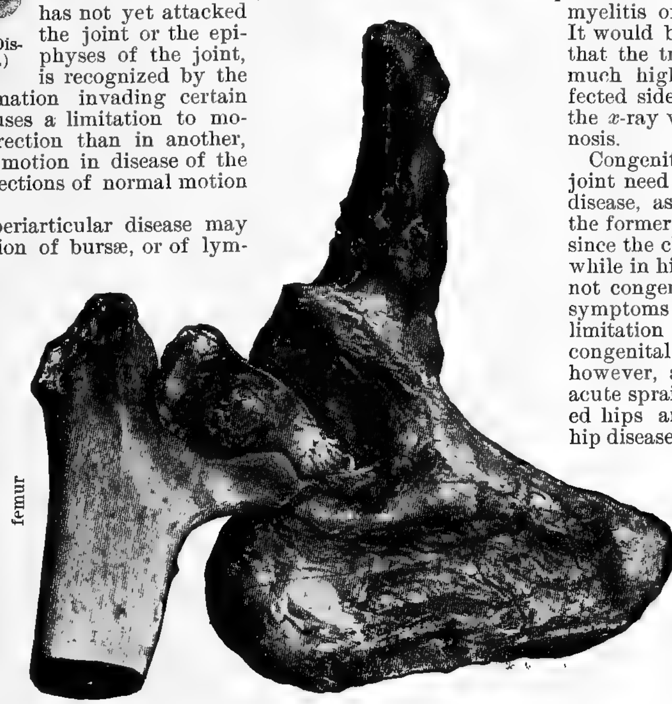


FIG. 3010.—Specimen of Coxa Vara; no clinical history.

It has been supposed that an anæsthetic would be an aid in the diagnosis of hysterical coxalgia, but this is not the case, and the latter can ordinarily be recognized without difficulty.


FIG. 3011.—Coxa Vara.

A traumatic separation of the epiphysis of the femur at the hip needs here scarcely more than mention, it is a rare accident occurring only before puberty.

Separation of the epiphysis from the diaphysis may occur in severe hip disease as well as in acute osteomyelitis of the neck of the femur. It would be recognized by the fact that the trochanter has assumed a much higher position on the affected side than on the normal, and the *x*-ray would establish the diagnosis.

Congenital dislocation of the hip-joint need not be mistaken for hip-disease, as the clinical history of the former is one of continued limp since the child commenced to walk, while in hip disease the limping is not congenital. There are also no symptoms of muscular stiffness or limitation of motion of the hip in congenital dislocation. There are however, at times cases in which acute sprains occur in such dislocated hips and during this condition hip disease might be simulated.

Coxa Vara, which is a bending of the neck of the femur, is, in many cases, accompanied by symptoms of joint irritation. There are shortening, elevation of the trochanter above Nélaton's line, and pain, but the only characteristic limitation of motion

is in the direction of abduction. The x ray should clear up the diagnosis.

Impacted Fracture of the neck of the femur occurs in children, and in its acute stage resembles hip disease somewhat. The signs are the same as those of coxa vara after the irritation has passed, and an x-ray examination would establish the condition at any time.

Arthritis Deformans of the hip may occur in children and resembles hip disease so closely that no established

FIG. 3012.—Tumor Albus. Acute Case of Marked Severity.

rules for the differential diagnosis have been formulated. The x-ray would be the chief reliance. The early symptoms resemble hip disease closely, and only when it has become evident that a chronic inflammatory process is persisting with little or no destructive tendency, should the condition be seriously suspected. It is apparently comparatively uncommon.

Infantile Paralysis of the muscles about the hip is accompanied in some cases by symptoms of joint irritation which are at first hard to differentiate from those of true hip disease.

Acute Infectious Osteomyelitis in the neighborhood of the hip is a condition occurring at times and simulating very severe hip disease. Abscess forms rapidly and the presence of pyogenic organisms in the pus is suspicious, as they do not as a rule occur in tuberculous abscess. The rapidly destructive character of the process, in connection with the results of a pathological and bacteriological examination, would suggest its presence. The x-ray should be of value.

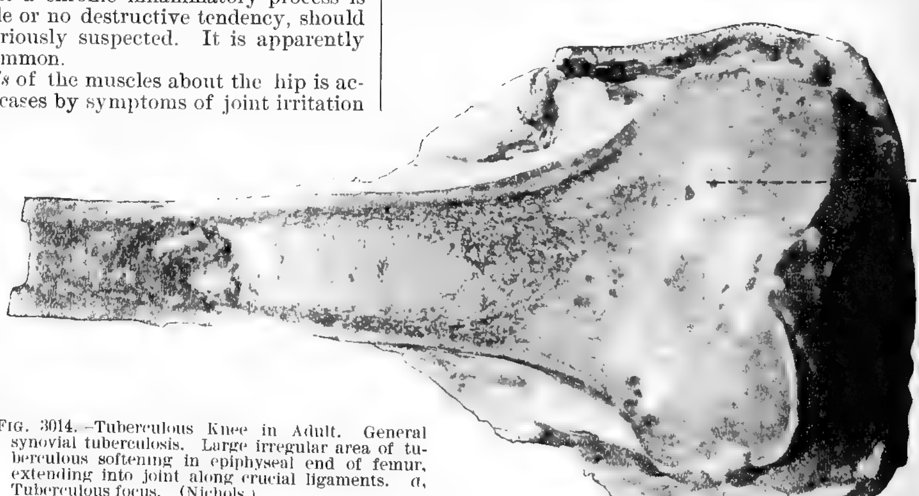


FIG. 3014.—Tuberculous Knee in Adult. General synovial tuberculosis. Large irregular area of tuberculous softening in epiphyseal end of femur, extending into joint along crucial ligaments. *a*, Tuberculous focus. (Nichols.)

II. *Synovitis of the Hip-joint.*—Serous synovitis of the hip-joint is not uncommon. In a majority of cases, its existence must be inferred rather than demonstrated.

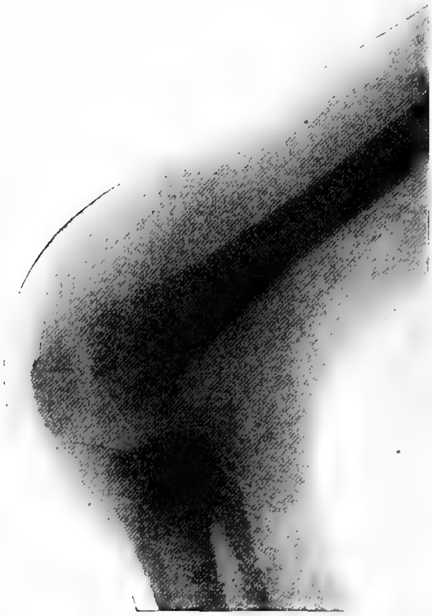


FIG. 3013.—Radiograph of same Case as Fig. 3012, showing Indistinctness of Lower End of Femur, where Focus of Disease is Situated.

It is not uncommon to see cases with the usual symptoms of hip disease at an early stage, viz., limping gait, muscular atrophy, stiffness, restriction of motion at the joint, peculiar and characteristic attitude, and slight pain persisting perhaps for weeks, yet in which complete recovery takes place in a few weeks or months. In a case of this sort death occurred from intercurrent disease six months later, and the remains of a synovitis, in the form of thickening and congestion of a part of the synovial membrane, were found.

The course of acute, subacute, or chronic synovitis of the hip-joint (if limited to the synovial membrane and not extending to the cartilage or bone) is not so protracted as that of epiphyseal ostitis.

Synovitis of the hip-joint from traumatism may occur in sprains and contusions; the extent and course of such

synovitis depend upon the nature and amount of the injury. In patients with a predisposition to tuberculosis, such injuries may produce tuberculous disease.

III. *Arthritis Deformans* of the hip-joint (senile coxitis, malum coxæ, malum senile, etc.), occurs chiefly in adults, but in children at times. It may be limited to the hip or it may occur in connection with disease of the other joints. Hypertrophic changes such as enlargement, thickening, and increase in density, occur in the head of the femur, or the changes may be atrophic. The synovial membrane shows the characteristic appearances. The symptoms are pain, painful movement, especially in hyperextension and rotation, a limp, and stiffness of the joint, and there may be a creaking of the joint on manipulation. There are atrophy of the muscles and, later, muscular fixation, with perhaps resulting deformity, until finally in severer cases the joint becomes stiff in a normal position or perhaps adducted or flexed. The condition does not go on to suppuration. The differential diagnosis from hip disease is aided by the x-ray. Hip disease is as a rule more acute, especially in adults, more rapidly progressive, than arthritis deformans. In children a differential diagnosis is difficult.

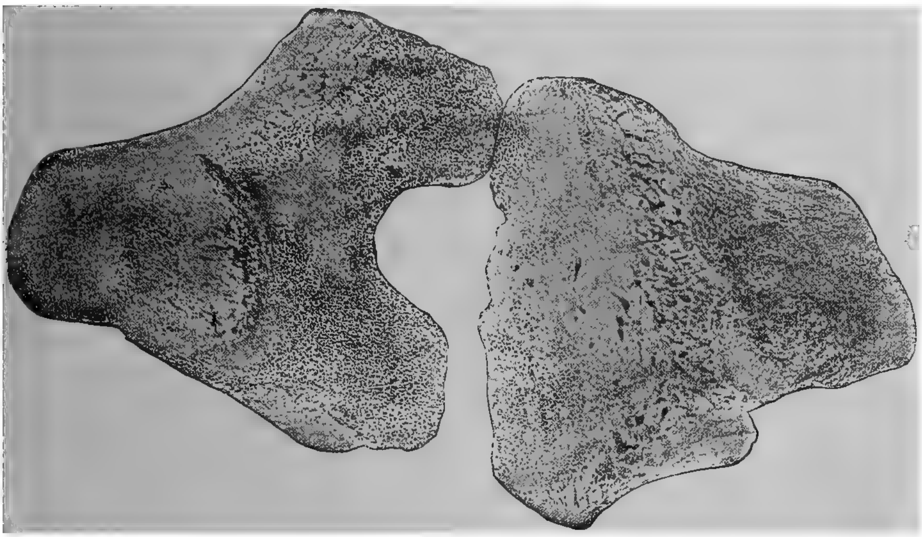


FIG. 3015.—Tumor Albus. Appearance of dry bones.

DISEASES OF THE KNEE-JOINT.—Of the common chronic affections which are found in the knee-joint, *tumor albus*, or tuberculous ostitis, is the most important (Figs. 3012 and 3013). This is also known as tuberculosis of the knee-joint, scrofulous disease of the knee, and chronic purulent or fungous synovitis of the knee. This condition begins most often as an inflammation of the epiphysis (Fig. 3014); usually either the tibial or the femoral epiphysis is first affected; occasionally the primary focus is in the patella or in the head of the fibula. In severe cases a destructive, fungous, or purulent synovitis generally develops, and it may end in complete destruction of the joint, or in arrest and recovery by absorption and cicatrization (Fig. 3015). The disease begins insidiously with stiffness and limp in gait. The head of the tibia or the condyles of the femur become enlarged or the whole joint may be attacked with swelling, pain, and effusion into the joint; there is usually elevation of surface temperature; and, later, flexion or subluxation of the limb at the knee occurs as the result of long-continued muscular spasm. If the condition persists for any length of time enlargement of the bone is characteristic. The swelling is that of bone and periarticular tissue and not altogether due to fluid in the joint. If this condition of the joint develops and there is much fluid the patella floats. There are tenderness on pressure about the joint and atrophy of the thigh and calf muscles. Shortening is not usually present until late in the disease and there is usually lengthening caused by the overgrowth in all directions of the tibial and femoral epiphyses due to the inflammatory hyperæmia. Actual pain may be absent, but is usually present in acute cases and may be severe. Muscular fixation is less prominent than in hip disease and in the early stages may be absent. Lameness is always present. The distortions which occur are due to the greater power of the flexor muscles of the thigh as compared with the extensors (Fig. 3016). The limb in severe and untreated cases is most often gradually flexed from the first, and unless treated flexion may reach a right angle. Accompanying severe flexion and subluxation is external rotation of the tibia or the femur resulting from long-continued muscular spasm. Sometimes an abscess develops in the joint and it may spread to the periarticular structures; in which case it is accompanied by acute symptoms.

Chronic Synovitis.—Chronic synovitis may occur in the knee-joint and is of the usual type. It is usually the result of the acute or subacute forms or may be due to exposure, wet, or cold, or follow an injury or sprain. It may be due to dislocation of the semilunar cartilages, to loose bodies, to elongated synovial fringes, and to the constitutional affections mentioned above.

One form of the affection is *Intermittent Hydrops*, which is an affection without discoverable anatomical basis, and without proof of infection; it gives rise to a simple non-inflammatory serous effusion in the joints, occurs at regular periods without any apparent reason, and is associated in some instances with what are usually classed as functional nervous disorders. The disease seems to be a functional, as opposed to an organic, trouble. Vari-

FIG. 3016.—Subluxation in Tumor Albus.

ous drugs are advised, some of which have at times been successful; change of air and surroundings may also be of use. But if all these measures fail, it is best to resort to exploratory incision of the joint and washing out or drainage (Brackett and Cotton, *Boston Medical and Surgical Journal*, vol. cxlv., No. 18, October 31st, 1901).

FIG. 3017.—Tumor Albus of the Knee.

In chronic synovitis swelling is marked and the patella floats. Tenderness is not marked except in acute cases, but it may be present on the inner side of the patella. Chronic synovitis of the knee-joint may remain indefinitely in a subacute condition, with a slight amount of effusion accompanied by thickening of the synovial membrane, or a large amount of serous effusion may take place with slight inflammatory symptoms. Chronic synovitis of the knee cannot always be differentiated from chronic tumor albus beginning as an epiphysitis.

Hydrops Articuli differs little from the ordinary type of synovitis. The chief symptom is effusion, which gradually develops and which disappears slowly, or which remains for a long time unchanged. In old and resistant cases of the ordinary type an exploratory incision is advisable.

Periarticular Disease at the knee is distinguished by the different location of the swelling, the absence of effusion in the joint, and the fact that the characteristic limitation of motions is not present. Bursitis is a common type of the affection.

Bursitis of the prepatellar bursa (housemaid's knee) occurs as a fluctuating swelling anterior to the patella; there is no fluctuation in the joint and flexion is slightly limited (Fig. 3018). Suppuration occurs in both the acute and the chronic cases in a certain proportion of cases. In chronic cases the bursa must be removed. In ordinary cases rest on a splint is sufficient.

The deep pretibial bursa may be affected, especially in children. The symptoms are apparent enlargement of the tubercle of the tibia, local swelling and tenderness, and limitation of full extension of the knee. The treatment is as described above. Bursitis in the hamstring region may occur.

Arthritis Deformans.—The pathological appearances have already been described. They are found more characteristically developed in the knee than in any other joint. The disease always develops gradually in persons of middle life or older. Occasionally it is seen in children. Effusion is not the rule, though it may exceptionally occur. Enlargement of the joint is almost constant. The symptoms are rarely acute, the most marked being a limping in gait, a sense of stiffness, especially after sitting for some time, limited motion, and eventually an irregular enlargement in the contour of the joint. The pain when present is usually caused by motion or jar; it is absent when the joint is at rest.

The disease is chronic, yet subject to acute exacerbations. It may produce complete disability from contraction of the limb, which is often strongly flexed.

The affection of the knee which occurs in tabes dorsalis clinically differs from chronic rheumatic arthritis but little, except that the disease is often much more destructive, causing complete disability with disorganization of the joint.

Dislocation of the Semilunar Cartilages (Hay's internal derangement).—The affection is traumatic in origin, and consists in the tearing loose of the internal or external semilunar cartilage from its tibial attachment. The internal one is the one most frequently displaced. A sudden twist on slight flexion or a wrench is the accident which most often causes this condition. The symptoms are effusion and tenderness over the cartilage, and there may be protrusion of one of the cartilages. The general history of the accident is that the leg was caught in flexion and that the pain was severe. The treatment consists in reduction of the dislocation (which the patient usually accomplishes himself), followed by rest and the ordinary treatment for the ensuing synovitis. Raising the inner border of the sole of the shoe is often serviceable.

The synovitis having been thoroughly cured, the patient is allowed to walk and to resume the use of the leg. If the dislocation recurs it is generally advisable to remove the loosened part of the cartilage by incision of the joint.

Dislocation of the Patella may occur spontaneously or in consequence of some slight twist of the leg. It usually attacks young girls with lax muscular fibre and a feeble development; boys are exceptionally attacked. The dislocation occurs most often outwardly (Fig.

FIG. 3018.—Prepatellar Bursitis ("Housemaid's Knee").

3019). The proper treatment is to extend the leg fully and then gently to press the patella back into place. Massage and electricity are indicated in all cases. Operative treatment consists in the removal of an elliptical piece of the front of the capsule of the joint internal to the extensor tendon, and a stitching together of the edges of the opening, thereby tightening the inner part of the capsule. In some cases the tubercle of the tibia has been transplanted to cure the affection.

FIG. 3019.—Patella Dislocated.

Synovial Fringes.—In certain conditions of the synovial membrane folds exist, which, if a laxity of the ligaments of the knee is present, may be caught between the moving bones forming the joint. This causes symptoms similar to those following a displaced meniscus, but more momentary in character.

Cysts of the Joint.—Subsynovial cysts may be formed about the knee-joint as about other joints; they may enlarge and produce an unusual appearance in the shape of the joint. In many instances they are connected with the joint by a small opening. A common place for such cysts is in the popliteal space.

It should be remembered that a number of bursæ are to be found about the knee-joint, and may become enlarged.

Rupture of the quadriceps extensor femoris may occur.

In *hæmophilia* a joint disease resembling clinically tuberculosis, occurs at times in the knee-joint. The symptoms are pain, swelling, and limitation of motion. The diagnosis is made by the history of the patient and the long continuance of the affection without much change. The treatment is protection and rest.

Functional disease (hysterical, neuromimetic) of the knee is to be recognized by the absence of objective symptoms and the prominence of subjective symptoms.

DISEASES OF THE ANKLE-JOINT.—In *chronic tuberculous disease* of the ankle the seat of the disease may be in the articular end of the tibia or the astragalus and other adjacent bones may be involved secondarily or simultaneously. There is usually little pain, and tenderness is present over the joint capsule in front, perhaps under the malleoli. Swelling, which is boggy, uniform, and œdematous in character, a feeling of heat over the joint, and marked muscular rigidity are present (Fig. 3020). Lameness is an early symptom, and the foot, owing to the abnormal muscular contraction, may be distorted, being in a position of equinus or calcaneus. Atrophy of thigh and calf muscles occurs and abscess may form. The diagnosis is made from the symptoms of limp, limitation of the motion of the joint, stiffness, swelling of the joint, pain, increased surface temperature, tenderness, and x-ray appearances. The other bones of the tarsus may be affected without involving the ankle-joint (Fig. 3021).

Chronic synovitis of the ankle may result from acute synovitis, perhaps the result of a sprain. The symptoms do not differ from those of chronic synovitis in general, and, as a persistence of the symptoms for many weeks or months may occur, the condition is sometimes spoken of as a chronic sprain in which disability of the foot results. In such cases any static disability of the foot is to be remedied. The ankle is to be supported as the occasion demands. The mobility of the foot is promoted by massage and manipulation, and the circulation may be restored by hot-air baths and douches.

Functional affections following sprains and injuries may occur, especially in hysterical women, and they are often difficult to diagnosticate, but careful consideration of the symptoms is usually sufficient. In such cases it is necessary to rule out organic disease, and to correct malpositions of the foot. The x-ray is of especial use in the diagnosis of ankle-joint disease.

DISEASES OF THE METATARSO-PHALANGEAL ARTICULATIONS.—These joints are occasionally attacked as a result of injury. In arthritis deformans they may also be attacked. Inflammation of the metatarso-phalangeal articulation of the great toe takes place as a result of the distortion of the toe called "hal-

FIG. 3020.—Ankle-joint Disease at an Early Stage.

lux valgus," or in-toe, the result of imperfect shoeing, and also secondarily to the affection commonly known as bunion. An ankylosis of this joint occurs in adolescents, being probably a sequela to a long-continued sub-

FIG. 3021.—Tuberculous Disease of the Ankle; Advanced Stage.

acute inflammation. Nothing especial need be said of inflammations of the phalangeal articulation, except that they are not common.

DISEASES OF THE SHOULDER-JOINT.—*Chronic Tuberculous Ostitis.* The general symptoms of ostitis of the shoulder differ in no way from those in the usual form of this disease in other more commonly affected joints; but stiffness at the joint is less noticeable on account of mobility of the scapula. The disease is insidious, extremely chronic, and decided impairment of the joint is certain to result. The earliest sign of this disease is pain, of a dull aching character, which is usually aggravated at night, and is referred either to the joint itself or to the middle of the arm near the insertion of the deltoid. In many cases this symptom is absent or very slight, and probably in these the origin of the disease is in the synovial membrane. About this time the patient is noticed to use the arm much less, and upon examination a certain amount of stiffness is found. A slight increase of surface temperature may be detected, but the thickness of the coverings of the shoulder-joint renders this uncertain. The deltoid and scapular muscles early show signs of atrophy, even at this stage. There will usually be found a tenderness, frequently localized over a small area, and it is often a prominent symptom, especially in epiphyseal disease. The patient instinctively holds the arm at rest, and any attempt at passive motion provokes muscular spasm, and, if this attempt is persisted in, the humerus and scapula are seen to move together.

Early in the disease a change in contour of the joint becomes apparent, and is due to enlargement of the head of the humerus as well as to muscular atrophy. This enlargement may not be symmetrical, perhaps more often presenting localized swelling representing the situation of the disease.

The course of the disease is slow; the early symptoms, which were perhaps slight, gradually become more pronounced, this being particularly true of the swelling and stiffness. The amount and character of the swelling depend upon the course of the disease. The stiffness may increase to complete, or almost complete, loss of motion of the humerus on the scapula. The natural depressions in front of and behind the joint become either obliterated or are the sites of prominences. When suppuration does not occur the symptoms gradually subside, the swelling disappears, and recovery takes place after several months, leaving a joint more or less stiff.

Chronic synovitis may also occur in the shoulder-joint. It has the characteristic symptoms and appears in those types already mentioned above, except that it is especially resistant to treatment.

Arthritis deformans also occurs in the shoulder-joint, and is associated with the same characteristic symptoms as are found in the other joints, namely, pain, swelling, and limitation of motions.

Periarthritis of the shoulder is described as a condition of stiffness following slight injuries. Pain, stiffness, and atrophy are its characteristics. The description of these not uncommon cases as periarthritis is not based on pathological evidence. The terms bursitis and synovitis would probably cover some of them.

The shoulder-joint may also be the seat of gonorrhœal synovitis, Charcot's disease, and synovial cysts, as well as of bursitis and tenosynovitis.

DISEASES OF THE ELBOW-JOINTS.—*Chronic Tuberculous Ostitis.* An *ostitis* frequently follows an injury to the joint, but in many cases it develops with no apparent cause. It usually occurs in children.

The disease may begin with pain, but this is not severe, and often is entirely absent. Limitation of extension of the forearm is a constant and early symptom, motion in this direction being distinctly restricted when flexion, pronation, and supination are free. A slight increase of surface temperature is usually found, but its absence does not exclude the disease.

Careful examination will reveal a slight amount of swelling even at this stage of the disease; it takes the form of a fulness and thickening on either side of the triceps, and, if we look at the elbow from behind, the joint appears broader than normal. As in other joints, wasting of muscles occurs, and in severe forms of the disease it is very great, especially on the forearm.

As the disease progresses the stiffness increases, motion in other directions is restricted and resisted by muscular spasm, and the joint is held at an angle of about 140°. Starting pains may be added to the other symptoms, and become the source of great discomfort. In severe cases the whole joint becomes involved in the swelling, the enlargement assuming a fusiform shape, and displaying a greater prominence on the lower radial side of the joint. As the cartilage disappears, and the destructive process in the articular extremities of the bone becomes established, the signs of abscess may appear.

Stiffness of the elbow without active disease may result from fracture, from synovitis with formation of adhesions, or from chronic arthritis of tuberculous or rheumatic origin. The elbow-joint may be the seat of Charcot's disease as well of arthritis deformans and synovitis with the characteristic symptoms.

DISEASES OF THE WRIST.—*Tuberculous disease* of the wrist is characterized by swelling, heat, and stiffness. If the disease is advanced deformity will be added and the hand may be flexed on the forearm to 120°–130°, a fairly constant symptom. There are atrophy of the muscles, heat, and limitation of motions. Suppuration is very likely to occur, and the course of the disease is long and slow.

Arthritis deformans when it attacks the wrist shows the ordinary symptoms of this affection which are seen in the other joints. The wrist is frequently flexed, and the fingers and hand are adducted.

Synovitis, and especially tenosynovitis, occurs in the wrist.

DISEASES OF THE PHALANGEAL ARTICULATIONS.—Owing to their increased liability to sprains, blows, etc., the phalangeal joints are frequently found enlarged, slightly deformed, and stiff, extension being limited.

Arthritis Deformans.—The hand is a very common seat of this affection, the disease often beginning in one or two joints of one finger, and a considerable period of time elapsing before others are attacked. The joints become much enlarged, and distortion usually occurs to

the ulnar side, this adduction being chiefly in the metacarpophalangeal joint.

The fingers remain permanently distorted, becoming flexed, or adducted, or both; the second phalanges of the fingers, as well as of the thumb, are usually extended, giving a characteristic appearance to the hand.

Diseases of the Sterno-clavicular and Acromio-clavicular Joints.—Enlargement of these joints sometimes occurs in persons accustomed to hard work with their upper extremities. Inflammation of the sterno-clavicular articulation, followed by destructive suppuration, is occasionally observed, but it presents no unusual symptoms.

Diseases of the Temporo-maxillary Articulation.—By far the most common affection is arthritis deformans; other diseases are rare.

Tuberculous disease may occur; it is usually secondary to disease of the ramus or of the ear.

Diseases of the Symphysis Pubis.—Inflammation of this joint has been described (see Holmes' "System of Surgery," article, "Diseases of Joints"). A relaxation of this joint may occur in pregnancy.

Diseases of the Sacro-coccygeal Joint.—Inflammation of this articulation has been mentioned as following injury.

Treatment of Chronic Joint Diseases in General.

In cases influenced by constitutional states constitutional treatment is manifestly indicated, and the reader is referred to the articles on *Tuberculosis*, *Rheumatism*, *Gout*, etc., for details of appropriate medication. It is self-evident that the better the patient's health is, the better are his chances for recovery, even in affections comparatively localized. In tuberculous joint affections the benefit of fresh air and exercise is particularly to be borne in mind.

The general methods for surgical and local treatment of chronic diseases of joints may be enumerated as follows: (1) local applications (counter-irritation, cauterization, inunctions, frictions, massage, douches, hot-air baths, subcutaneous injections); (2) compression; (3) fixation; (4) protection from jar; (5) distraction (extension). In addition to these the operative measures (aspiration, incision, excision, and amputation) are needed at times.

Local Applications.—The benefit to be derived from local applications comes chiefly from an alteration in the circulation of the parts and a relief of a condition of congestion, if such exist. Blisters, counter-irritation, and cauterization play less of a part in modern therapeutics than formerly, but in certain cases they appear to afford relief. The application, however, of heat and cold is of undoubted benefit in some cases.

Friction and massage, in certain cases, by improving the circulation, improve also the condition of the joint. It is probable that in this way galvanism is beneficial.

The benefit of inunctions is probably that of frictions generally; that is, there is established an improvement in circulation and with it a diminution of congestion. The application of moist heat—poultices, wet-pack—is often agreeable. And if there is inflammatory heat in the part, the application of cold in some form (douche, compresses, ice-bags, Leiter's coil, etc.) will be found advantageous.

Compression.—Compression promotes absorption of fluid from œdematous tissues or from the cavity of a joint. It can most readily be applied to the knee by means of rubber bandages or other elastic compresses. Dried compressed sponges bandaged around a knee and then wet, will, by expansion, produce pressure in cases of chronic synovitis of the knee-joint or hydrops articuli, and they are occasionally used in this manner. Elastic cloth or flannel bandages can be used, but sheet rubber bandages will be found best. In arranging for compression, it is important that the pressure should be exerted chiefly on the synovial membrane and affected tissues, and not on the more prominent healthy parts of the bone. To effect this, thick felt pads cut so as to fit in the depression are sometimes needed, and the bandage is to be placed over the depressions of the joint, as at both sides of the patella or of the malleoli.

Fixation.—Fixation, *i.e.*, the prevention of motion at a joint, is indicated in all active inflammatory conditions of a joint. In subacute conditions of inflammation a limited amount of careful motion is not injurious, the amount of motion varying according to the state of the joint. Sudden, violent, or jerky motion is, however, injurious.

In cases of active synovitis pure and simple, there is manifestly greater indication for fixation than for protection, the reverse being true in epiphyseal ostitis in a subacute stage. Passive motion, massage, active motion, and forcible motion of a joint, all may be indicated in stages of convalescence, for the purpose of breaking up and stretching adhesions, or to diminish the thickening of the synovial membrane. Motion being a normal function in a joint, it is manifest that as much motion should be permitted as is compatible with the inflammatory state. The question when fixation should be interrupted and passive or active motion allowed, is one of judgment in each case. It should, however, be borne in mind that passive motion begun too early, or employed with too great force, is apt to increase the existing synovitis, and the ultimate recovery of the joint is thereby retarded rather than hastened. It should also be remembered that the absence of pain or tenderness does not indicate the absence of ostitis and the safety of unprotected motion in a joint. Bone is not a sensitive structure, and there is comparatively little increase of sensitiveness accompanying a subacute localized ostitis.

Passive motion is of more use in combating periarticular contractions than in cases of pure arthritis, and it is for the prevention of these chiefly that passive motion is advisable. But it is also true that motion is a normal function of a joint, and that its tissues are not in normal condition unless this function is brought into use.

Protection.—Protection from the jar incidental to locomotion is of importance in ostitis of the joints of the lower extremities, except in the latest stage of convalescence; and fixation, that is, prevention of flexion or extension, or the normal motion of the joint, is important in the acute stages of synovitis. The importance of protection is often overlooked in the supposition that, if a knee or ankle is fixed by a stiff bandage, the patient can bear weight upon the limb, forgetting that in an ostitis jar to the inflamed epiphyses is more injurious even than motion. The simplest method of protection in affections of the lower extremity is by the use of crutches, but, as will be seen under the headings of individual joints, other more convenient means can be used. Protection from jar in joints of the upper extremity is readily effected by the means used for fixation.

Distraction.—The "distraction" of the bones forming a joint, that is, the pulling them apart, is manifestly desirable when the inflamed epiphyses are being crowded together, either by jar or muscular pressure. Exaggerated pressure of two inflamed bony surfaces of a joint upon each other increases the danger of necrosis, and the extent of the destructive ostitis, by diminishing through pressure the blood supply proper to the separation of the inflamed parts, and the development of the formative or cicatricial ostitis, from which a cure is to be expected. In certain joints, as the elbow, sacro-iliac, symphysis pubis, distraction is impracticable, and in certain others, as the shoulder, it is not difficult, while in the hip it is of great importance. In pure synovitis, where there is no danger of extension to the bone, there is little need of distraction.

The operative procedures, aspiration, arthrectomy, and arthrotomy, will be considered severally under the headings of each joint, where they are to be borne in mind as therapeutic methods.

The employment of these several methods varies not only in the different affections of the joints, but also in the different joints, certain methods being especially adapted to the anatomical conditions of certain joints. The subjects, therefore, will be separately considered under the heads of the various joints.

Treatment of Individual Joints.

Hip-joint.—The indications in treatment of tuberculous disease of the hip are to furnish, severally, fixation, distraction (extension), protection for the benefit of the patient's general condition; to prevent and correct deformity; to allow locomotion as far as is compatible with the surgical indications, and to meet such complications as periarticular inflammation, abscess and sequestra, as may arise.

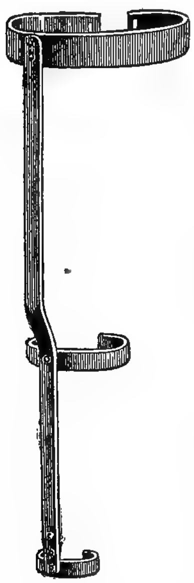


Fig. 3022. — Thomas' Hip Splint, Single. (Ridlon.)

Treatment, it is manifest, should be adapted so that it can be continued not only during the active and subacute stages of the disease, but also during the convalescent period, and until the affected joint is able to stand the jars incident to locomotion without fear of recurrence of the disease.

Fixation.—The means generally used for fixation are: 1. Plaster-of-Paris bandages, or leather and metal splints applied to the hip, pelvis, and thigh, for fixation. 2. The Thomas splint. 3. Gouttière de Bonnet, "wire cuirass," or some modification of it.

Plaster bandages furnish an imperfect form of fixation: owing to the necessary expansion and contraction of the thorax in respiration it is impossible to hold the thorax firmly, and, owing to the mobility of the lumbar spines, the pelvis is able to move within the bandage, thus allowing motion of the acetabulum and distortion of the limb.

Thomas Splint. The Thomas hip-splint, introduced by Mr. Thomas, of Liverpool, is an appliance used in England, and has many points of usefulness (Fig. 3022). It does not, however, furnish complete fixation, nor does it prevent the occurrence of subluxation, or counteract the spasmodic muscular contraction of the muscles connecting the lower extremity with the pelvis—so important a feature in hip disease. The appliance, however, prevents motion of any noticeable amount, enables the patient to be lifted without jarring the hip, and prevents flexion of the thigh. In certain acute cases the pain may be increased by the Thomas splint, from the fact of the imperfect fixation furnished. The leg and thigh are firmly held by the appliance, *i.e.*, by the flat rod, to which they are bandaged. This rod extends up the trunk, and cannot be so firmly fixed to the trunk but that some motion is possible at its upper end, as the patient turns in bed or moves. Motion of the upper end of the rod is, of course, communicated to the lower, and the joint may, in this way, be twisted and jarred by the long lever attached to the thigh (Figs. 3023 and 3024).

A. B.

Fig. 3025.—*B*, Specimen from Excision of Hip Treated by Efficient Traction for Three Years. (Operation done because of failure in general condition.) *A*, Specimen from excision of hip when traction had not been employed. In severity and duration the disease was similar to that of *B*.

Wire Cuirass. The Gouttière de Bonnet, or wire cuirass, furnishes excellent fixation. It is, however, cumbersome and expensive, and has the defect of not thoroughly giving the benefit which can be afforded by distraction, in relieving the increased intra-articular pressure. A distracting force can be added, making the appliance of service. The difficulty of manufacture and the expense of the apparatus render it of less use than simpler arrangements.

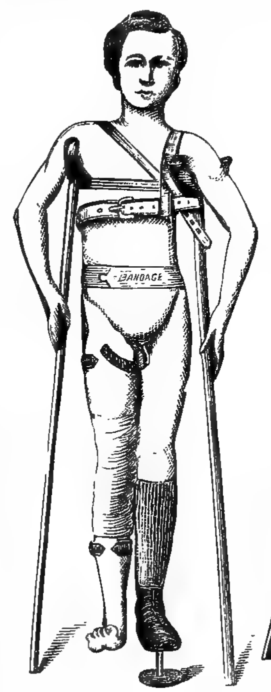


Fig. 3023.—The Thomas Splint Applied. Front view.

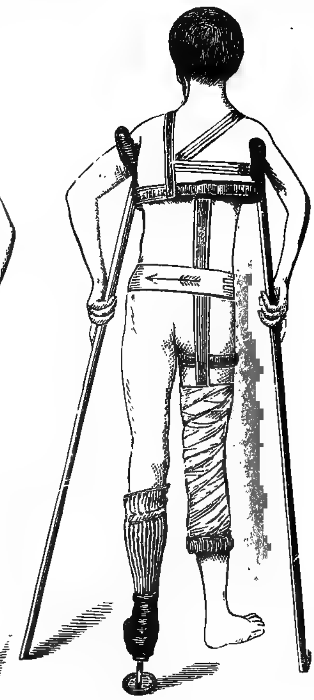


Fig. 3024.—The Thomas Splint Applied. Posterior view.

Distraction.—All the above methods of attempted fixation overlook the injurious influence of muscular spasm of the muscles about the hip, in spasmodically jarring the hip-joint, and in exerting an undue pressure by crowding the inflamed epiphysis of the femur against the acetabulum. This reflex spasm of the muscles about a joint is constant in all inflamed joints surrounded by muscles. It is of special importance in hip disease, from the strength of the muscles about the joint. Such spasm prevents rest of the joint, increases the pressure on the inflamed bone, causes distortion of the limb, absorption of the head of the femur, enlargement of the acetabulum, and subsequent subluxation of the femur. The force of the pressure can be estimated if we consider the great strength of the muscles extending from the pelvis to the femur. A sudden spasmodic

contraction of all these muscles drives the head of the femur against the acetabulum with the force of a sharp

FIG. 3026.—Traction in Hip Disease.

blow, and unless this is overcome, no attempt at securing rest of the joint is complete.

To counteract this injurious muscular force, a pull upon the femur away from the acetabulum is necessary. This is often instinctively attempted by patients, who press the foot of the well limb on the dorsum of the foot of the affected side, in the endeavor to force the limb away from the acetabulum (Fig. 3025).

The influence of a distracting force has been denied by some writers, who claim that it is impossible to draw the femur away from the acetabulum. This is not only disproved by clinical experience, in the relief afforded by a distracting force properly applied, but the distracting effect of such force has been demonstrated by experiment (Bradford and Lovett, Children's Hospital Report, 1895).

The head of the femur is held close to the acetabulum by the cartilaginous collar (cotyloid ligament), which is a prolongation of the acetabulum. In a healthy hip-joint, if all muscles are dissected away, it will be found difficult, if not impossible, to pull the femur from the acetabulum, if the pull is exerted in the line of the trunk; if, however, the limb is abducted, and a pull exerted in a direction not counter to the strength of the ligament, actual distraction takes place.

In a fœtus, or young child, distraction is easy from a downward pull in almost all directions, for the cotyloid ligament of a fœtus is not well developed. In hip disease the cartilage becomes softened and practically absorbed, and therefore cannot offer the resistance to distraction which is to be met in a healthy joint.

If a distracting force be applied with the limb strongly adducted, the head of the femur is brought against the rim of the acetabulum. This is not the case if the limb is slightly adducted, or if the acetabulum has not attained its normal adult development. But in well-marked hip disease in children, with softening of the cotyloid ligament and imperfectly developed acetabulum, distraction is as feasible as at the metacarpo-phalangeal articulation of the forefinger, where the bones of the joint can easily be separated by traction.

The effect of distraction can be readily estimated by any surgeon, if, in excision of the hip, before dislocating the head of the femur, the finger is placed on the head of the femur close to the rim of the acetabulum. If an assistant pulls upon the limb, the finger can be inserted between the head of the femur and the acetabulum. If the traction is discontinued, the pressure upon the finger will be found to be considerable. This pressure does not, of course, indicate the pressure due to muscular force, which is obliterated under an anæsthetic.

A distracting force can be applied therapeutically, by means either of the well-known weight and pulley method, or of distraction splints.

The former method of distraction or, as it is commonly termed, "extension," is frequently employed, and is often of great assistance, but it is often inefficiently applied.

The following mistakes are not uncommon:

1. The use of a weight too small to counteract the muscular spasm at the hip.
2. The neglect of a counter-extending force, or the use of an imperfect one.
3. Imperfect hold upon the leg and thigh.
4. Improper fixation of the patient's trunk and limb, allowing motion so that the distraction will fall upon the knee and not upon the hip-joint.
5. The use of the pulling force in such a direction that the force is not exerted in the line of deformity.

FIG. 3027.—Patient on Ward Wagon, with Arrangement for Fixation and Traction.

(*a*) The amount of weight to be used should vary according to the case; the patient's sensation may be trusted in a measure. In cases of severe spasm as much as twenty pounds will be found to be well borne in light cases, and in small children four or five pounds will be ordinarily sufficient.

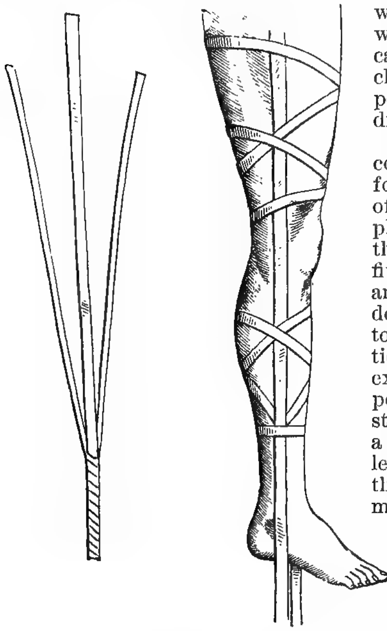


FIG. 3028.—Adhesive Plaster for Traction.

(*b*) The readiest counter-extending force is the weight of the body employed by raising the foot of the bed five or six inches, and causing a tendency of the body to slide in a direction opposite to the extending force. A perineal strap or straps attached to a weight and pulley, or fastened to the head of the bed, may be used.

(*c*) The best way to obtain the hold upon the limb for an extending force is by means of adhesive plaster applied as is indicated in the accompanying diagram. It should be applied firmly to the thigh above the knee, so as to secure efficient traction upon the condyles of the femur. If applied to the leg alone, distraction falls upon the knee, and may cause relaxation of the knee-joint. Efficient plaster should be used, of a kind that will adhere readily without being heated. The plasters should be changed every three or four weeks, or oftener if they cause irritation. They can readily be removed, if the skin and plasters be thoroughly moistened with benzin. If any portion of the limb is chafed by the plaster, it may be protected by means of a cloth placed over the part, and the plaster reapplied over the cloth and the whole limb; or if the chafing is extensive, the whole limb can be covered with vaseline and protected by a smooth bandage, and the plaster put on over the bandaged limb. This will require frequent renewal, but will answer temporarily. It is usually the practice to apply a bandage over the plaster, but this impedes the circulation, and increases the danger of eczema or chafing. If a bandage be applied, and worn for a few hours after the plaster is first put on, sufficient adhesion of the latter will be secured if proper plaster is used.

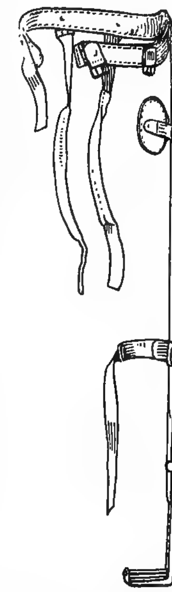


FIG. 3030.—Long Traction Splint, Slightly Modified. (Fiske Prize Fund Essay.)

(*d*) If the patient be allowed to roll about in bed, or sit up, or to hold the limb flexed at the knee, it is manifest that no proper distracting force is used. The patient, if restless, should be secured by the use of shoulder straps fastened to the bed, and by the use of sandbags; or, better still, he may be restrained by means of the bed frame to be described.

(*e*) The ill effect of a pulling force not in the line of the deformity, in acute stages of hip disease, is evident; the psoas and iliacus muscles being contracted by the spasm incident to the disease, the thigh is flexed. If an attempt is made to force the limb down, and traction be made in the line of the axis of the body, the head of the femur is crowded upward to the anterior edge of the acetabulum, by the force applied at the end of the lever, viz., the femur, the attachment of the psoas and iliacus muscles, holding the limb flexed, furnishing the fulcrum. In milder stages of the disease this is not so important as in the acuter stages, but it is a mechanical error in any stage to attempt distraction except in the line of the deformity (Fig. 3029).

FIG. 3029.—Patient in Bed on Fixation Frame, with Traction in Line of Deformity.

Joints.

Distraction Splints. A number of appliances have been devised for the purpose of "distraction," the principle of which is practically the same, viz., perineal resistance with a pulling force exerted on the limb. As in most appliances, however, the details of the application of these principles are of so much importance that the efficacy of such treatment will depend on the details (Figs. 3030 and 3031).

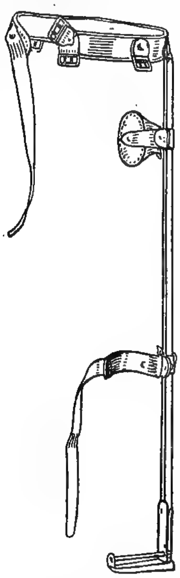


FIG. 3031.—Long Traction Splint. (Fiske Prize Fund Essay.)

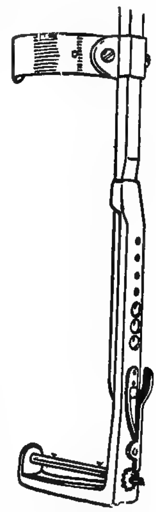


FIG. 3032.—Windlass and Ratchet Appliance for Extension. (Fiske Prize Fund Essay.)

For efficient distraction by means of splints, it is important: (1) That it be possible to adjust the splint so that the amount of distracting force can be regulated and properly applied. (2) That the perineal resistance be arranged so that great pian shall not be caused in that way if efficient force is applied. (3) That a proper hold upon the limb be possible for some time. The latter has already been discussed in speaking of the weight-and-pulley method.

The perineal resistance should be so fixed that the perineal straps do not constrict the thigh. The straps should not be elastic and yielding, giving an uncertain resistance, and they should be made of proper material and padded, so that they do not wrinkle or cut at the edges. If the perineum be well anointed with vaseline, and the straps be properly made and padded, no serious trouble need be encountered.*

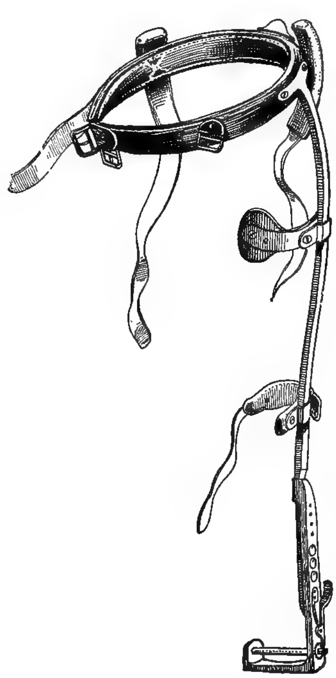


FIG. 3033.—Long Traction Appliance. (Children's Hospital Report.)

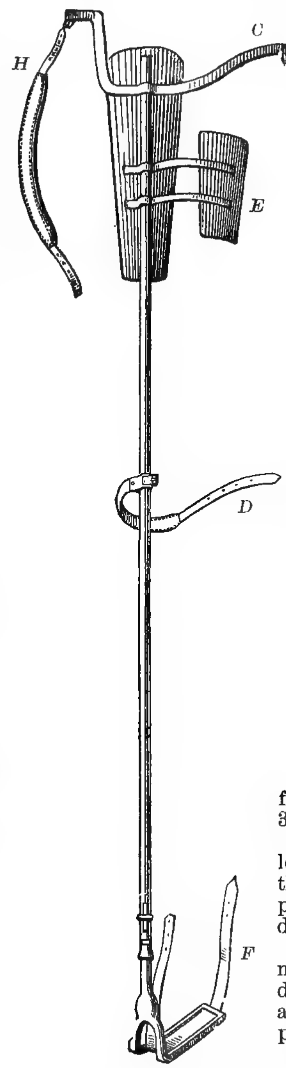
The first of the essentials of treatment above mentioned is easily accomplished, usually by means of a sliding rod moving within a tube, the amount of motion being controlled by means of a key and ratchet, a spring securing the rod when in the proper position. This constitutes the well-known Davis-Taylor extension splint, illustrated in Figs. 3033 and 3038.

* An excellent modification of the perineal strap to be used, devised by Dr. Brackett, will be found described in the Boston Medical and Surgical Journal, October 6th, 1887.

A traction splint manifestly furnishes certain advantages over the method of distraction by weight and pulley, in that distraction by the first of these methods is possible while the patient is going about.

A short traction splint was at one time in use, but it cannot be relied on as efficient.

The distraction splint consists of a rod, A, hollow at the lower part into which a rod, B, with teeth cut on the edge plays, by means of a key, G. The rod can be moved up and down, and it is caught and held in place by means of a spring, I, and sliding catch. The lower end of B is furnished with a broadened end, bent so as to pass under the foot, and through which a strap, F, can be slipped which is attached to buckles secured to the adhesive plaster on the patient's leg. To the upper end of A is secured an arm, C, which passes in front of the thigh, and to which a strap, H, passing under the perineum, can be buckled. A plate, E, in front of the thigh, keeps the splint from slipping backward, and the arm D passes under the thigh and holds it firmly, and prevents the splint from slipping forward (Fig. 3034).



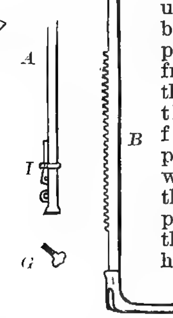


FIG. 3034.—Distraction Splint.

The arm C can be made longer, so as to pass around the waist, and hold a second perineum strap passing under the other buttock.

The splint is necessarily modified somewhat to fit different patients, but the above diagram illustrates the principle.

It has been claimed by some writers that if thorough distraction is employed, fixation beyond what is furnished by the distracting appliance is unnecessary.

Although this may be true theoretically, and practically many cases may be successfully treated without complete fixation, yet it cannot be assumed as a surgical aphorism, that, where fixation is indicated, it can be furnished by a distracting force.

It is also true that thorough fixation of the hip is not possible without distraction. Efficient fixation can be furnished in the following way, illustrated by the accompanying diagrams (Figs. 3030 and 3035).

Protection.—By preventing injurious jar from being inflicted upon the affected joint, the joint may be said to be "protected." The simplest way to protect a joint is with the use of crutches, the sound limb being raised by

means of a patten on the shoe of that side, enabling the affected limb to swing free of the floor. The weight of the limb exerts a certain amount of distracting force, and it was at first supposed that hip disease could be treated

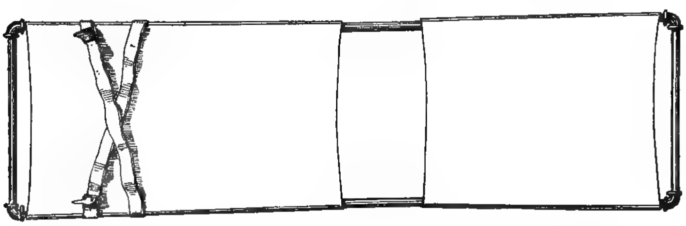


FIG. 3035.—Gas-Pipe Frame. (Children's Hospital Report.)

in this way alone. Although this supposition has not been justified by facts, and it has been found that distortion of the limb and subluxation will not be prevented by this method, yet excellent protection can often be secured in this way.

It will be found, however, that in many cases, especially among children, it is difficult to prevent them from discarding crutches before it is safe to do so, or from kneeling upon the affected limb and in that way endangering the hip. Crutches also demand the use of the arms, and in adults the use of the arms for other purposes is desirable in the long period during which protection is needed. A protection splint is therefore of importance. The ordinary "extension" splint, as shown in Fig. 3030, is in reality a protecting as well as a distraction splint, as it is longer than the limb and passes under the foot, enabling the weight to be worn upon the splint instead of the patient's foot. Protection without distraction can be furnished by omitting the sliding rod, and continuing the upright rod below the foot, and expanding it at the bottom, as in the extension splint, or by inserting it into a socket in the boot. The rod should be long enough, and the boot so arranged that the patient's heel shall not touch the sole of the boot, though the ball of the foot may do so. The greatest jar in locomotion comes as the heel strikes the ground at the commencement of the step. If this jar is broken by the splint, the remaining jar to the hip in the step will be diminished at the ankle and knee, and the hip will be sufficiently protected, except during the acuter stages of the disease (Fig. 3037).

A protection splint can be made hinged at the knee, and if properly adjusted patients can walk about readily with but slight discomfort. In this way reliable protection is secured during the long period of convalescence necessary for the thorough ossification of the affected epiphysis.

If proper protection is neglected and not continued for a sufficiently long time, the jar of locomotion—the whole weight being thrown upon the epiphysis previously carious—is sufficient to prolong the stage of irritability, to prevent complete cicatrization and ossification of the inflamed bone tissue, to promote contraction of the limb and distortion, and in many instances to give rise to relapses.

An appliance which will not interfere with locomotion, which will readily allow walking and the free use of the arms, which is not a great disfigurement, and can be worn without discomfort for years if necessary, is of great use in the convalescent treatment of hip disease. It not only prevents relapse, but also prevents deformity. It is, of course, indicated only in the convalescent stage, and would be injurious in an acute stage.

Simple protection without distraction is not to be relied upon if muscular spasm is present; this point can be determined by palpation of the muscles of the hip. If muscular spasm is present, protection and distraction should both be employed.

Summary of Treatment.—The proper treatment of hip disease is not the exclusive use of any splint or method (*i.e.*, of rest or extension), but the use of such means as may meet the indications that are present. During the acute stages, the hip-joint should be fixed efficiently. This implies rest in bed, with fixation, and the use of efficient traction. Continued confinement to bed is not beneficial for the general condition of tuberculous patients, except temporarily during the acute stage; and as soon as the acute symptoms have subsided the patient should be allowed to go about with the hip protected against jar and spasm as far as is practicable. This can be done in a measure by means of a distraction splint, if efficiently applied in cases which are not in the most acute stage, but it should be remembered that complete fixation of the hip is impossible during locomotion (Fig. 3036). Thorax fixation by a Thomas splint, stiff spica in addition to traction, increase the mobility of the trunk, but add to the awkwardness of the appliance.

At first crutches will be found an aid in locomotion. If the acute symptoms return under this method, thorough fixation and rest in bed are again indicated. If the subacute symptoms diminish and there is less muscular rigidity at the hip-joint, greater freedom can be allowed, and eventually distraction discontinued, and the joint merely protected from jar. This should be continued as long as there is any danger of recurrence of active symptoms or any tendency to contraction.

In brief, the hip should be fixed as long as it is sensitive, should be protected and distracted as long as there is muscular spasm, and protected as long as it is weak.

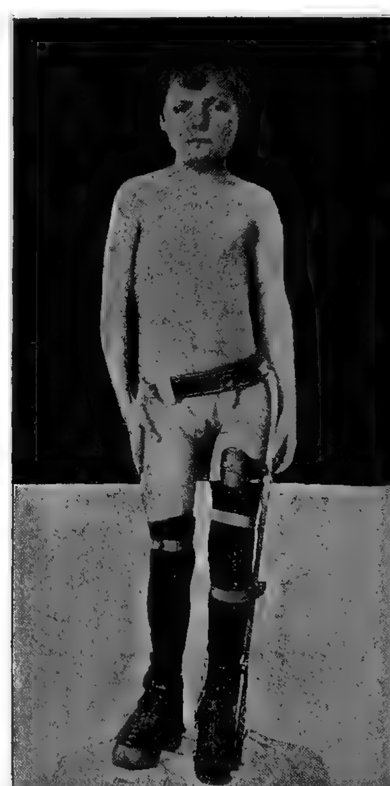


FIG. 3036.—Long Traction Splint Applied. (Fiske Prize Fund Essay.)

The best results are attained only by great care for a year at least, and careful supervision and protection for two or three subsequent years. Distortions of the limb should always be prevented, and in many cases some motion can

be saved at the hip-joint, if protection is not discontinued too soon.

Excision of the Joint.—In the severer cases of hip-joint disease, the question of excision demands consideration.

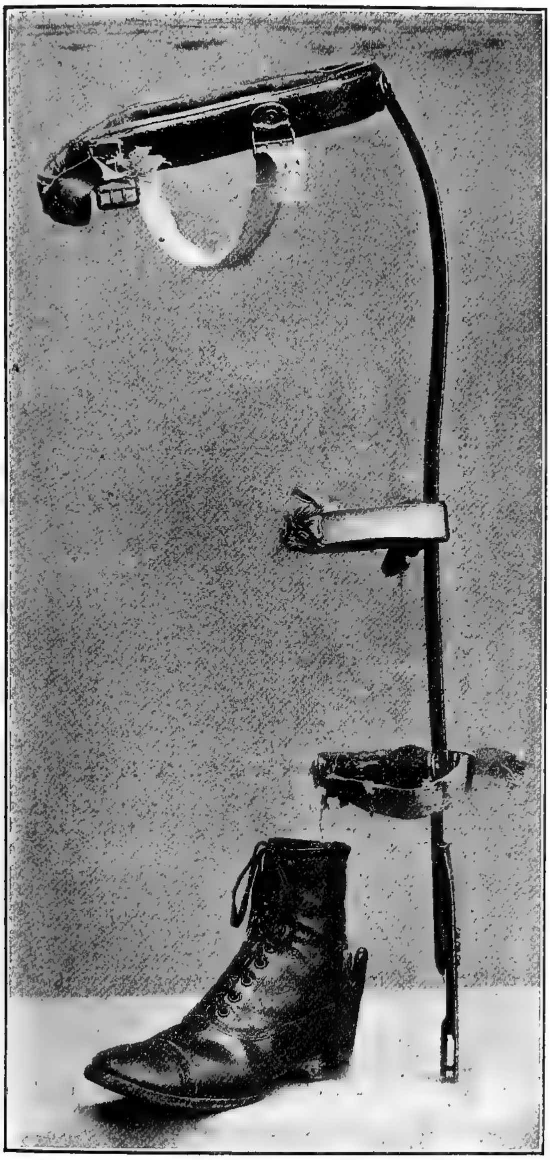


Fig. 3037.—Protection or Convalescent Splint.

The ultimate results after excision are not so satisfactory as at first supposed. The operation is in itself not a very dangerous one. If early excision is done, the percentage of recoveries is quite large, and excellent motion at the joint is often retained with the formation of a new joint. The results, however, are inferior, as a rule, to those procured by conservative measures.

A committee of the Clinical Society of London, appointed to investigate the subject of the ultimate usefulness of the limb after hip-joint disease, reported the following result of their investigation of 320 cases: The percentage of mortality was 40, and of recovery 42. In 15 per cent. death followed directly from the operation; in 13 per cent., from phthisis; in 6 per cent., from albuminoid nephritis; in 4 per cent., from other causes not connected with the hip affection. The treatment of those who recovered lasted one year and three-fourths, the duration of the affection was three years, and the average shortening of the limb was two and three-fourths inches. The indications for resection, as reported by the committee, were as follows: (1) Necrosis of the head of the femur and separation into loose sequestra; (2) firm sequestra of the head of the femur and the separation into loose sequestra; (3) extensive caries of the femur or pelvis, with fistulæ; (4) pelvic abscesss, with disease of the acetabulum; (5) old chronic synovial suppuration, with disease of the cartilages of the acetabulum; (6) luxation of the femur on to the ilium, with chronic suppuration and fistulæ, a condition indicated by early suppuration and general symptoms.

Aseptic surgery has apparently reduced somewhat the mortality from excision at the hip-joint, but has not increased the usefulness of the limb after excision nor in any way prevented a relapse.

Of 121 operations of excision performed on 119 patients, 2 were double, analyzed by Townsend;* 113 had abscesses or sinuses; in 5 cases the spine as well was involved; in 2, the knee; in 2, the tarsus; in 3, the ilium; in 18, the acetabulum was seriously diseased, and 10 had osteomyelitis of the shaft of the femur. In 99 of the 119 cases, the later results showed that 52 were dead and 47 living. Of the 52 deaths, 9 were directly due to the operation shock; 28 were due to exhaustion; 7 to other causes. Of the 47 living, 26 were cured.

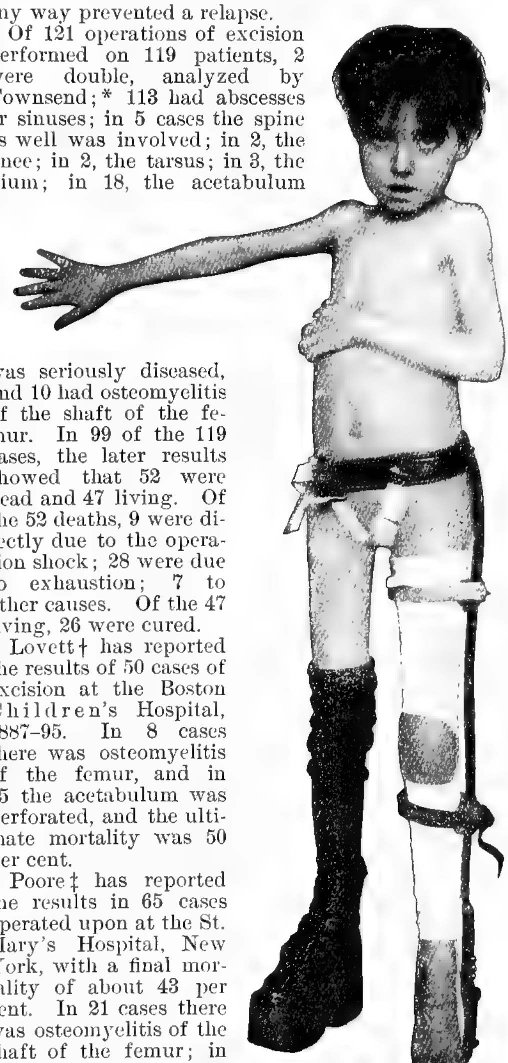


Fig. 3038.—Long Traction Splint Applied.

Lovett† has reported the results of 50 cases of excision at the Boston Children's Hospital, 1887–95. In 8 cases there was osteomyelitis of the femur, and in 15 the acetabulum was perforated, and the ultimate mortality was 50 per cent.

Poore‡ has reported the results in 65 cases operated upon at the St. Mary's Hospital, New York, with a final mortality of about 43 per cent. In 21 cases there was osteomyelitis of the shaft of the femur; in 11, perforation of the acetabulum, and in 9 of these the opening communicated with an intrapelvic abscess.

For further details as to the procedure of excision, the reader is referred to the article on *Resection*.

As a substitute for excision, König, Volkmann, and

* Med. News, June 26th, 1897.
† New York Med. Jour., April 23d, 1892.
‡ Trans. Am. Orthopedic Assn., vol. x.

others have advised, and successfully carried out in certain cases, a method of operative treatment by cutting down upon the bone and removing the diseased portion of the epiphysis by the chisel or curette, without sacrificing the joint. Such a method, however, is possible only in early cases, and in cases in which the joint proper is as yet unaffected. These cases are rare, and are recognizable only through the help of the x-ray.

Amputation.—Of the still more radical method of amputation little need be said here (see *Amputation*) except that, in cases of extreme hip disease, it is often to be regarded as a life-saving measure. The percentage of mortality of amputation for hip disease is not so great as that of amputation for injury or malignant disease.

Ashhurst* says that in 34 cases of primary amputation at the hip-joint for hip disease and in 31 cases after excision, he found 19 deaths. The death rate of amputation after injury is 70.9 per cent., and for the disease in general 42.6 per cent.

Wyeth† and Levison‡ show a mortality for the operation by Wyeth's method of 11 in 85 cases, *i.e.*, 15.29 per cent. In the Children's Hospital, Boston, there were 3 cases, and the operation was successful in all, but later 2 patients died of amyloid disease.

In cases of disease of the acetabulum, in which the head of the femur is but little involved, excision of the head of the femur alone is of little benefit. Excision of the acetabulum is a formidable undertaking with a heavy percentage of mortality. As a substitute for this, the following procedure has been tried in a few cases: The joint is cut down upon, and the head of the femur pulled from its position and placed upon the dorsum. A large drainage tube made of celluloid is placed through the incision, long enough to reach to the acetabulum, which is wiped with strong carbolic or corrosive; any sequestrum which may remain is to be removed. If the drainage tube is allowed to remain, the carious acetabulum can be dressed frequently, thoroughly drained, and the bone is free from irritation caused by the rubbing of the head of the femur upon the acetabulum. This procedure is of value only in the severest cases. It will be found that pain will be relieved and the patient given a chance for recovery.

The limb after the operation is secured by a plaster-of-Paris spica. Shortly after the operation the patient can be allowed to walk about on crutches. Correction of the resulting deformity is deferred until all sinuses are healed.

It will be found that in cases of extreme sensitiveness of the hip, in the early stages without much destruction of bone, where night cries are insistent, that these can be relieved by securing the limb in a forced flexed and abducted position, using a plaster-of-Paris spica, including the leg, thigh, and trunk. The patient is kept in bed and the limb is slung from above. This places the limb in a position unfavorable to spasmodic action of the muscles, which action is instrumental in causing night cries. After a few weeks the limb can be brought down to the proper position and treated as is possible in a subacute stage.

Treatment of Complications.—Abscess. In certain cases of hip disease the epiphysitis is either so diffuse or so slight that the cicatricial process follows the inflammatory process of the bone without undue cell proliferation; but in others the tuberculous focus is neither encapsulated nor absorbed, but is sloughed out, and, causing an irritation, an abscess follows. This again may be absorbed or it may require treatment.

Simple cold abscesses secondary to hip disease can with safety be left to themselves, if not causing constitutional disturbance or increasing rapidly. It is desirable, however, that pus should be prevented from burrowing or extending in a great variety of directions. This can, in a measure, be done by bandaging the limb, and is done if an extension splint is worn efficiently; the pus being checked from extending along the sheath of the fasciæ by the resistance caused by the perineal strap and the pressure of the padded plates. If the abscess extends, it is well localized in a large majority of cases, and can extend only outwardly.

Aspiration is of assistance in many instances; in some, however, either the fluid contained in the abscess does not flow readily through the aspirating needle, or the latter is directly plugged by the caseous clots. In some instances abscesses have been entirely absorbed after one or two aspirations.

Injection of iodoform into an abscess cavity or hyperdistention by carbolic-acid solution have been recommended. The latter involves the occasional risk of carbolic-acid poisoning, which may be fatal.

Abscesses that are well localized, if allowed to open spontaneously, are often thoroughly evacuated, leaving a sinus which, discharging for some time, finally heals. Often, however, the abscess is not completely evacuated. Some residue remains, and, gravitating along the lines of fasciæ, gives rise to another abscess, and in this way several may be developed about the joint. It is better in such cases to open the original abscess freely, so that thorough drainage is furnished—large incisions being better than small. If that is done, with thorough asepsis and proper dressings applied, it is not uncommon, when active disease of the bone has subsided, for such abscesses to heal up entirely by first intention, without recurrence or sinus. To gain such results two things are essential, viz., thorough drainage of the whole abscess and perfect asepsis. It is, of course, necessary that thorough treatment for the ostitis be not interrupted.

Nocturnal Cries. A troublesome complication in the early stages of hip disease is often the nocturnal cry. This usually disappears after thorough fixation with distraction. In some instances, however, the cries persist for weeks or months. They are likely to disappear in the second stage of the affection; they can be checked by opiates, narcotics, chloral, or chlorodyne, if not stopped by proper fixation. Stretching the sciatic, trephining the head of the femur, and direct incision of the joint have been advised and tried with success in aggravated cases of this sort.

Distortion. Distorted attitudes of the limb are incident to the clinical history of hip disease, and the correction and prevention of them form an essential part of treatment. In the earlier stages of the disease there is little difficulty in correcting the existing deformities due to abnormal muscular contractions or malpositions of the limb—the ordinary treatment of hip disease being sufficient to correct deformity. If distraction is applied in the line of the deformity, in the early stages of the disease, it will be found, in a few days, that the limb can be placed in a more nearly normal position until it eventually becomes straight.

The deformities occurring are flexion, abduction, and adduction. Flexion can be corrected by efficient traction in the line of the deformity, as already mentioned. It will be found that a traction splint is more efficient for this purpose than the simple weight and pulley; the patient should be fixed in bed, a traction splint applied, the flexed limb raised to the angle of deformity so that the back is flat, and, if necessary, the weight and pulley may be attached to the splint in order to give additional fixation to the limb. It will be found that each day the angle of deformity is less and the limb can be lowered. Flexion can also be corrected by means of the Thomas splint bent to fit the flexed limb and gradually straightened. In the severe cases rest in bed hastens the correction in this way.

Abduction usually corrects itself under the ordinary treatment for hip disease, or is changed to adduction in the natural course of the disease.

The same may be said of adduction, but this latter distortion is often more persistent. It can often be corrected by the ordinary weight-and-pulley method, with fixation in bed. The correction can be helped by counter-extension applied to the well limb, by means either of a perineal strap or of a weight-and-pulley arrangement attached

* Int. Encyclopedia of Surgery, vol. vi., p. 501.
† Wyeth: Ann. of Surgery, xxv., 1897, 127.
‡ Levison: Jour. Am. Med. Assn., June 24th, 1899, p. 1428.

Joints.

to the sound limb, and pulling at the head of the bed in opposition to the force on the affected limb pulling at the foot of the bed. The result of the two forces is to correct the adduction.

In later stages of severer deformity forcible straightening under an anæsthetic, with or without division of the adductor tendons and the division of the fascia lata, or with division of all fasciæ by open incision, is of help.

Of all the operative procedures subtrochanteric osteotomy is the preferable one in bony ankylosis with deformity.

In cases of deformity with fibrous ankylosis, correction can be made by mechanical means, but in the severest cases much time and patience are required.

In cases with subluxation and absorption of the head of the femur and enlargement of the acetabulum the deformity entailed is necessarily permanent so far as the alteration of the bone is concerned, but the accompanying flexion and abduction can be corrected. Subluxation and the attendant distortion should not occur in the course of hip disease, as they are preventable, and their presence indicates a lack of thoroughness of treatment.

Shortening of the Limb.—Shortening of the limb after hip-joint disease and after excision occurs in a certain number of cases without satisfactory explanation; the shortening is not limited to the femur, but occurs also in the tibia and fibula and the foot. Nothing can be done to prevent this arrest of growth. Prevention of the development of the disease and such use of the limb as is compatible with safety of the joint (inducing proper circulation in the limb) may be regarded as the only means at our command.

Prognosis of Hip Disease.—Judging from the limited statistics at our disposal, the prognosis of hip disease in regard to life and to recovery of a useful limb is encouraging, but a long time is required in all cases.

Cazin reports that in 80 cases of suppurative hip disease treated at the hospital at Berck, in the course of five years, 55 per cent. were cured, 12.5 per cent. died, 25 per cent. were not cured, 7.5 per cent. were improved when removed. Cazin has seen recovery in desperate cases. In 15 cases of suppurative coxitis with albuminuria, 5 were fatal under conservative treatment, 2 were discharged improved, 6 not improved, and 2 cured.

These cases of Cazin were, all but 10, severe cases, sent from the Paris hospitals after they had ceased to improve there.

In 150 cases of Gibney, Waterman, and Reynolds in the Hospital for Ruptured and Crippled in New York, 107 were cured. Of these 107, 21 cases had no shortening, 7 had one-quarter inch, 12 one-half inch, 24 one inch, 22 one to two inches, 9 two to three inches, 4 three to four inches, 1 six inches.

Of 288 cases collected by Gibney, there was a mortality of 12.5 per cent. from exhaustion, meningitis, and amyloid degeneration. C. F. Taylor, of New York, has reported 94 cases in private practice, with only 3 deaths; 24 of these cases were suppurating, and of these 17 fully recovered.

Hueter reports the mortality of hospital cases at 27 per cent., and Billroth at 31 per cent.

Shaffer and Lovett* investigated 51 cases of cured hip disease which had been discharged from the New York Orthopedic Dispensary at least four years previously, and found that 41 had remained cured. Of the remaining 10, 4 had died and 6 had relapsed, although 5 of the latter had been apparently cured a second time. The above cases were under treatment as follows:

2 years.....	4 cases.	4 years.....	8 cases.	6½ years	1 case.
2½ "	4 "	4½ "	2 "	7 "	1 "
3 "	9 "	5 "	2 "	8 "	1 "
3½ "	6 "	6 "	1 case.		

In estimating the chances of an individual case, not only the severity of the disease has to be considered, and the amount of resistance or recuperative power on the part of the patient, but also the amount of intelligent and skilled care possible in the case for a long time.

In few diseases is the benefit of thorough and long-continued treatment more clear, and in few surgical affections can the surgeon attempt to check the progress of disease and influence recovery with greater probability of success than in hip disease; but the surgical care and supervision should not be limited to the acuter stages of the affection, but should be continued during the convalescent stage if the best results are desired.

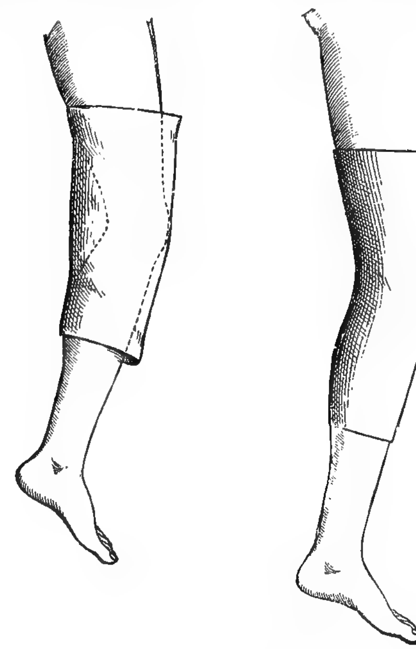


Fig. 3039.—Imperfect Fixation of the Knee by Plaster Bandage.

Knee-joint.—In considering diseases of the knee-joint, the varieties—synovitis, ostitis, etc.,—have to be much more sharply borne in mind than is true of other joints, as these different diseases are clinically more easily distinguished and more common, and the differences more important. The methods of treatment common to all joints—viz., fixation, distraction, protection—are especially needed in affections of the knee. Fixation can be carried out in the knee-joint with much thoroughness. Effective fixation can be accomplished by means of stiff splints, by stiff bandages, plaster silicate, starch, etc.

The splint or bandage should be as long as possible in order to overcome the lever action of the segments of the limb above and below the joint. An additional reason for making the appliance of sufficient length is found in the fact that the thigh is well covered by soft tissues, and a certain amount of motion is possible owing to the yielding of the soft parts (Fig. 3039). Osteotomy may be necessary in bony ankylosis at a flexed angle (Fig. 3040).

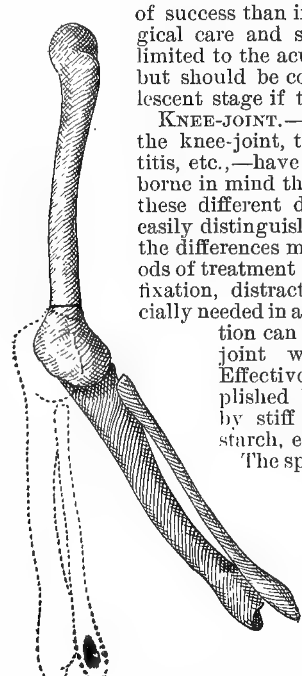


Fig. 3040.—Osteotomy for Deformity with Ankylosis. (After Hoffa.)

Distraction of the knee-joint is practicable in a relaxed

* New York Medical Journal, May 21st, 1887.

condition of the ligaments and capsule. In a healthy knee-joint it is impossible to separate the tibia from the fibula owing to the strength of the lateral and crucial ligaments.

Counteraction of the reflex muscular spasm, so important in disease of the hip-joint, is needed in the knee chiefly to overcome the tension of the hamstring muscles, which tend to cause a subluxation of the tibia.

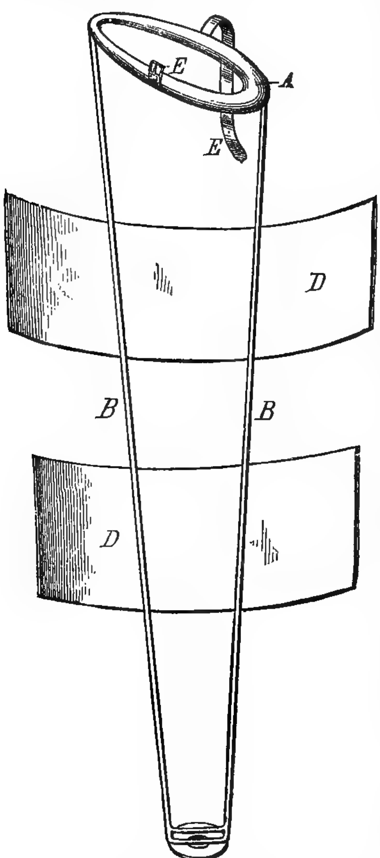


Fig. 3041.—Protective Splint for Knee and Ankle. (Thomas' Knee Splint) for right leg. *A*, Perineal ring; *C*, foot piece; *D*, leather lacings; *E*, straps to go over shoulder.

When there is a diseased condition of the epiphysis, and as long as that condition remains, the joint is incapable of bearing pressure or weight, and needs protection. Protection from jar is compatible with locomotion by means of crutches, or of an appliance longer than the limb, with arrangement for perineal support.

Compression is most readily applied to a knee-joint by means of a thin rubber bandage wound about the limb; bandages of elastic cloth can also be used, but are not so efficient. Dried and compressed sponges, bandaged firmly about the limb, will expand when wet, and in this way compress the tissues of the joint effectively; or the knee may be thickly covered with sheet wadding and binders' board made pliable by immersion in hot water, and the whole bandaged firmly.

Tuberculous Ostitis.—In epiphyseal ostitis the treatment requires the greatest care to preserve the function of the joint as far as is possible, to arrest the progress of the disease, and to prevent and correct deformities. Fixation is demanded in the acute stages and should be thorough; in the subacute stages some motion is at times allowable, and in the stage of convalescence as much motion as is possible without direct jar to the joint should be allowed. Protection is demanded in all stages of the disease, and distraction in the acute and subacute stages. Aspiration of the joint, incision, injection into the joint, counter-irritation, may be all indicated, and in the severe cases excision or arthrotomy.

What was said in regard to the treatment of hip disease may be repeated in speaking of epiphysitis of the knee-joint. The treatment should be thorough, persistent, and should meet the indications. Fixation and protection are the most important indications in diseases of the knee, distraction being less so. The employment of protection should be continued until it is certain that the epiphysis is normal, a matter of judgment in every case. Protection should be discontinued gradually and tentatively; if discontinued too soon, recurrence will take place, or the deformity at the limb will increase. Fixation should be used so long as there is any activity of the inflammation; this is indicated by pain, muscular spasm, or tenderness. Efficient fixation of the knee does not require confinement to bed.

Protection can be furnished by means of crutches, raising the sound limb by a thick sole, and allowing the affected limb to swing clear of the ground. Better protection is furnished by means of a splint (with perineal support) longer than the limb and passing under the foot so as to take the jar of locomotion (Fig. 3041). The best of these splints is one similar to that already described as a protective splint in hip disease. It can be readily set at the angle of flexion of the knee and straightened as the limb straightens, and distraction can be added to the splint if necessary.

A simpler appliance is the Thomas knee-splint, which consists of a padded iron ring fitted so as to surround the thigh at the perineum, and fastened to two rods, one on each side of the limb, longer than the limb and secured at the bottom to a metal plate below the foot (Fig. 3042).

In cases of extreme disease of the knee-joint amputation of the thigh is necessary as a life-saving measure. In less severe cases the limb may be saved by excision (for the details of this procedure the reader is referred to the article on *Resection*). As for the indications determining a choice between excision and amputation, it can be said that where the patient's reparative power is slight an amputation is to be preferred. The question is largely one of individual judgment.

One danger from excision in children is that of arrest of the growth of the limb, from removal of the epiphysis.

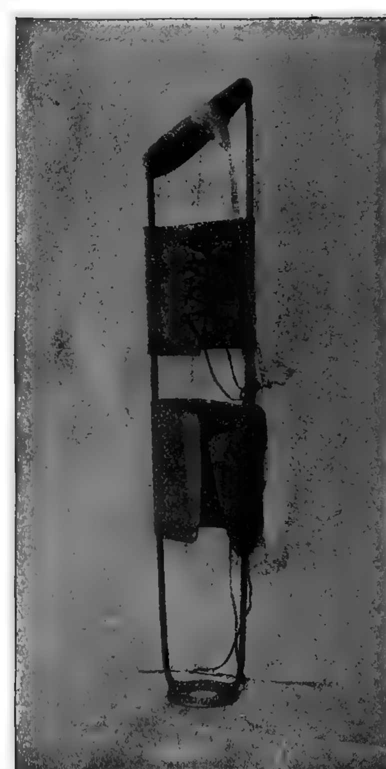


Fig. 3042.—The Thomas Knee Splint. (Children's Hospital Report.)

For this reason erasion has been advised in children as a substitute for excision. The joint is opened as in cases of excision, and the whole synovial membrane as far as it is tuberculous should be dissected out; if carious spots are found in the bone these foci should be removed

by the curette or chisel. If the whole epiphysis is diseased excision is of course unavoidable, but in many cases this is unnecessary. Schede, Volkmann, and others have reported excellent recovery with complete healing without suppuration in a few cases of this sort, and similar success has followed the procedure in two cases in the practice of the writer. Strictest asepsis is essential, as well as a thorough removal of all tuberculous tissue in the affected joint, necessitating sometimes complete dissection and removal of all of the synovial membrane, as well as careful curetting of the bone. The patella should be removed or left according to its condition. Either two straight incisions, one median incision, or a cross incision may be used. The patella may be divided and subsequently wired, or the ligamentum patellæ cut across. All tuberculous tissue should be removed by the chisel, curette, or scissors.

Statistics in regard to the ultimate results of treatment of disease of the knee are unfortunately of little value as a guide in the consideration of proper treatment of disease of the knee-joint; it may be said that aseptic surgery has materially improved the chances of recovery after excision, and that conservative treatment in children gives most excellent results in cases which can be watched and treated for a long time. The following figures are given by Willemer of cases treated in the course of seven years at the Göttingen Clinic (see *Deutsche Zeitschr. f. Chir.*, 1885, Bd. 21, Heft 4):

The treatment was fixation by plaster-of-Paris bandages preceded by extension, and with or without incision of abscesses, curetting, etc.; or by resection, partial or complete; or amputation. Of the patients *not operated* upon, in three years, 19 per cent. recovered, 15 per cent. died, 66 per cent. were still under treatment. In four years, 26 per cent. had recovered, 17 per cent. had died, 57 per cent. were uncured. At the end of five years, including all cases operated on or not, 29 per cent. remained uncured, 11 per cent. had been amputated (with a mortality of 60 per cent.), 37 per cent. had been resected (with a mortality of 51 per cent.), and 13 per cent. were well without operation.

It should be borne in mind that these figures represent hospital cases, presumably cases treated under more or less unfavorable circumstances.

Periarticular abscesses are to be treated in the same way as cold abscesses are treated in connection with other joints.

The results of conservative treatment of the tuberculous knee-joint may be excellent, but in severe cases a long time is necessary. In adults the prognosis of the conservative treatment of severe cases is much less satisfactory. The reverse may be said of excision.

Prevention and Correction of Deformity.—The deformity most frequently accompanying chronic epiphyseal ostitis is flexion; this can, in the early stages of the disease, be easily corrected by manual straightening under an anæsthetic, by a pulling force with a weight and pulley, by a distraction splint, by bandages and a fixation splint, or by repeatedly applied plaster bandages. If the deformity, flexion, remains uncorrected for some time in severe ostitis of the knee-joint, a subluxation of the tibia backward takes place, due to the contraction of the hamstring muscles. If an attempt be made to straighten the limb, the head of the tibia is held in its subluxated position by the contracted hamstrings in the posterior capsular ligaments, and if the leg is brought into the direction of the thigh the head of the tibia will be found behind its normal position and an ugly deformity will have resulted. This can be prevented only by a forward force exerted on the head of the tibia, pushing it around the end of the femur as the limb is straightened. Various appliances have been used for this purpose, and by the use of long-continued and persistent effort correction can be effected by proper splints (Fig. 3043).

In angular ankylosis at the knee resection for correction of the deformity is not without danger. Poinsot collected seventy-seven cases, with a mortality of eight per cent. This was, however, before the days of aseptic surgery, for the same writer collects thirty-six operations and no death when aseptic precautions were used. For the correction of deformity which has persisted for some time, forcible straightening under an anæsthetic is often necessary; or, in cases of bony ankylosis, osteotomy or excision (see *Resection*). In fibrous ankylosis the readiest way to correct is first forcibly to flex (in order to break up adhesions without increased danger of rupture of the artery) and then extend, dividing the hamstring tendons, if need be, beforehand. Mechanical appliances are often recommended for the purpose of straightening, but are unnecessary if the following procedure be carried out in difficult cases. The patient is placed upon the floor on his back, and the surgeon stands over him holding the knee with both hands, the fingers being placed under the popliteal space. The patient's ankle is grasped between the surgeon's knees. The whole weight of the surgeon's trunk can then be thrown upon the end of the lever furnished by the leg, the hands of the surgeon pulling upon the popliteal space furnishing the resistance. After the limb is forcibly flexed and the adhesions are broken, it can be straightened if the patient is turned upon the face; a downward force being applied to the heel, and resistance being furnished by a cushion placed under the patient's knee. When subluxation is present it must be corrected, and this can be done by means of an appliance which will, however, be needed only in extreme cases.

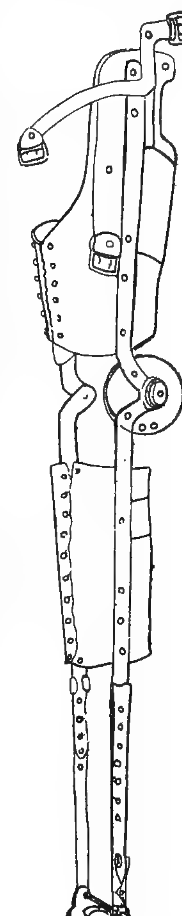


FIG. 3043.—Splint for Traction on Knee at any Angle.

After correction of the deformity, the limb should be well surrounded with soft cotton and a stiff bandage applied, the limb being held straight until the plaster has become hard. The procedure is sometimes followed by pain, and opiates are necessary for a few days. In the lighter cases no such force is required, but the limb can, under an anæsthetic, be brought into position by manual manipulation.

The dangers incurred by this procedure are not so great as would be supposed. Such a violent procedure should not be undertaken if there is inflammation present at the joint, but in the early acute stages little force is required to straighten the limb. The danger of rupture of the artery can be avoided by care. Separation of the epiphysis of the femur may take place, but is cured by the fixation requisite to treatment, and should not occur if the force is carefully applied. Fracture of the femur and tibia can be avoided by care.

Synovitis.—In chronic synovitis without effusion thorough fixation is needed in the early or acuter stages, with or without compression. The application of cold by ice-bags, evaporating lotions, cold douches, or the cold coil will often be a help, and in some instances hot cloths or poultices relieve pain. Counter-irritation, by means of tincture of iodine or blisters, and cauterization, are of doubtful value except as expectants.*

In chronic synovitis with serous effusion the treatment

* For the treatment of acute synovitis the reader is referred to the article *Synovitis*.

is primarily to cause the absorption of the fluid by means of compression and fixation. Besides this, distraction and protection—one or both—are needed if there is danger of extension of the disease to the bone or cartilage, and fixation if there is any activity of disease; the choice of massage, of passive motion in later stages, or of fixation, is a question of judgment in each individual case, it being borne in mind that motion is a normal function of a joint, and that massage may be supposed, by temporarily improving the local circulation, to promote the absorption of synovial œdema or its results, and, on the other hand, that anything which increases the inflammation in a joint, like ill-judged motion, is an injury.

When the inflammatory stage is passed and there is no further danger of extension of the disease to the bones or cartilage, massage, as well as passive exercises, may be allowed. Twists and sudden jars are to be avoided, and protection (crutches or splints) is advisable in the stage of convalescence if the attack has been at all a severe or protracted one.

In very resistant cases of simple chronic synovitis the joint should be incised and explored to find a cause if possible.

In synovitis with purulent effusion the joint should be thoroughly drained by incision and washed out. If the effusion is but slightly purulent, aspiration and thorough washing out will suffice. If, however, the pus is thick, or caseous clots are present, the joint should be freely opened by straight lateral incisions and well washed out with an aseptic fluid. The observance of strict aseptic precautions is of course necessary.

Hydrops Articuli.—In hydrops articuli (water on the knee) the treatment is such as would promote absorption or removal of the fluid. Besides friction and compression, which are often sufficient, aspiration is of great service. The procedure may be considered to be free from danger. The best method of applying is as follows: after a thorough cleansing of the skin, the knee is bandaged with a rubber bandage to exert slight pressure, a small portion being left uncovered for the insertion of the aspirating needle. This is best done at a little distance from the side of the patella. The size of the needle should depend upon the character of the fluid; if thorough asepsis is carried out a needle of large size or a trocar is free from danger. After the joint has been aspirated, the wound should be covered with a piece of aseptic gauze or cotton and a rubber bandage applied over the knee. If the fluid is again effused, the joint can again be aspirated.

When reproduction of fluid takes place, injection of iodine, as in the treatment of hydrocele, has been recommended and used, but sometimes the results have been disastrous. The injection of carbolic-acid solutions, or of corrosive-sublimate solutions, is apparently efficacious, as well as thorough irrigation of the joint already mentioned.

The treatment of *chronic rheumatoid arthritis of the knee* is the same as that of the same disease elsewhere, as may also be said of syphilis and gout. In some cases of chronic rheumatoid arthritis protection is sometimes of use, distraction is not necessary, and fixation should be applied only temporarily. Massage, hot applications, and electricity may be of benefit.

Loose Cartilage.—There are two methods for removal of loose cartilage at the knee: (1) The open incision, introduced by A. Paré, discarded by later surgeons, including B. Bell, who preferred amputation of the thigh, and revived again since the introduction of aseptic surgery; (2) the subcutaneous extraction, which is done as follows: the foreign body is pushed into the external upper cul-de-sac and held by the finger of an assistant under the triceps tendon, and by help of another kept from slipping up. An incision is then made with a tenotome in the subcutaneous tissue, directly under the synovial cavity, and in the synovial wall, directly under the foreign body, which is forced out into the cellular tissue; two weeks later the loose cartilage is removed by direct incision. The difficulties of the second step, namely, removal of the cartilage from the cellular tissue, are great, and several modern surgeons prefer the direct incision on account of the technical difficulty of the indirect method (*Revue de Chirurgie*, 1881, No. 1).

In removal of a loose cartilage by direct incision, an incision is made at the side of the patella, where the loose body is to be felt; the strictest asepticism is to be observed.

Displacement of the Semilunar Cartilage (internal derangement of the knee-joint) is the result of a sprain, and the symptoms and treatment are those of sprain at the knee with synovitis.

In the severest cases an anæsthetic is necessary in order to restore the cartilage to place, but after the cartilage is replaced by manipulation of the joint immediately after the accident, the knee is to be flexed to its fullest extent, the tibia pulled upon as if to draw it away from the femur, and rotated; the limb is then suddenly straightened, the operator pressing upon the displaced cartilage at the same time. The cartilage sometimes returns to its place with a snapping sensation, but often without the patient's consciousness. Frequently the patient learns, by a sudden twist of the limb, to replace the cartilage himself. In recurrent cases of dislocation it is necessary to remove the cartilage by direct incision.

Slipping of the Patella.—Occasionally, owing to an injury to the lateral fasciæ, or to a loss of tension of the quadriceps extensor muscle, the patella slips to the side, interfering with locomotion, and causing discomfort. The treatment has been spoken of earlier.

ANKLE-JOINT.—In the treatment of the most formidable affection of the ankle-joint, viz., tibio-tarsal ostitis, protection from jar is especially indicated, as will be readily seen, if it be borne in mind that in locomotion the whole weight of the body is borne at each step upon the comparatively small surface of the articulating portion of the astragalus. Fixation of the ankle in a stiff bandage and allowing the patient to walk upon the limb, is a manifest error, occasionally made possible through confusion of a simple synovitis, which at certain stages needs fixation, with ostitis, which should be protected from jar at all stages. Protection can be furnished either by means of crutches, or, more thoroughly, by means of protective splints with perineal supports. Protective splints, described for the knee-joint, are needed in ostitis of the ankle.

Fixation is of advantage in the acuter stages of the affection, and is readily furnished by means of stiff bandages.

If abscesses form, they should be incised.

In cases of tuberculous disease of the ankle, with extensive disease of bone, the decision to persevere in conservative treatment, or to resort to operative interference, is one which is based largely upon the patient's age, and the circumstances of attendant care.

In children, the results of conservative treatment are fairly satisfactory.

In adults, however, the treatment is much less satisfactory in advanced cases. Excision or amputation is not infrequently demanded in the worst cases.

Operative interference consists of curetting the sinuses or the removal of the diseased tarsal bones. It will be found that the latter procedure gives much the more satisfactory results when the ostitis has become so extensive as to have occasional sinuses; if it has involved a greater part of the astragalus; and if the curette is unreliable as a means of removing all the disease.

Chronic Synovitis of the ankle-joint is chiefly the result of sprains, and the treatment should be the same as that commonly used in the sprains of the ankle, viz., fixation, compression, massage, passive motion, occasionally protection; and the period of time required for the employment of these several methods varies according to the severity of the attack and the condition of the patient.

Fixation is readily furnished by stiff bandages, and compression by a rubber bandage. Care should be taken that the pressure comes upon the proper part of the ankle, and not upon the most prominent part, viz., the malleoli. The parts requiring pressure are the depressions in front

and behind the malleoli, and these should be filled with pads of cotton or felt, so that the pressure of the bandage shall fall upon the capsule of the joint, and not chiefly on the malleoli; if there is much swelling at the ankle, this precaution is not necessary; but as the swelling subsides the malleoli become more prominent, and would bear the chief pressure of the constricting bandage.

In severe chronic synovitis of the ankle-joint the indications are for rest, fixation, and, if swelling be present, compression. In cases in which there is danger of extension of the disease to the astragalus or tibia, protection is advisable.

In the lighter cases of synovitis of the ankle-joint, or after the inflammatory stage has passed, the need of perfect fixation is not present, and massage, with protected or graduated motion, will be found of great benefit.

METACARPO-PHALANGEAL JOINTS.—In chronic affections of the joints of the anterior part of the foot and of the toes, it is often desirable to allow locomotion without jar at the joint, and to avoid the incumbrance of crutches or of appliances.

The sole devised by Mr. Thomas, of Liverpool, seen in the accompanying diagram, will answer the indications

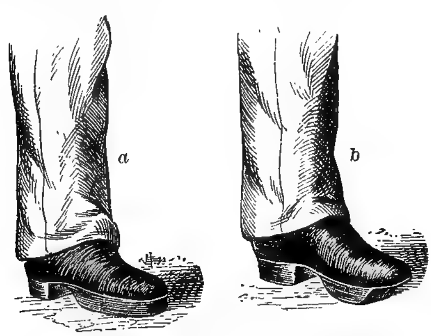


FIG. 3044.—Shoe for Metacarpal Disease.

of protection and fixation, at the same time allowing locomotion (Fig. 3044, *a*).

The shoe worn by the Chinese, with a thick stiff sole, cut away at a slant at the toes, answers the same purpose (Fig. 3044, *b*).

It is important, as a preventive measure, that shoes which are too short or which crowd the toes, should be avoided; the foot should also be prevented from slipping forward, crowding the toes against the front of the shoe This can be done by properly lacing the shoe against the instep and ankle, and furnishing a sole of sufficient length.

SHOULDER-JOINT.—*Chronic Synovitis.*—In synovitis of the shoulder-joint with any active inflammation, the indication is simply for rest and fixation. These are readily secured by means of a sling, and a bandage securing the arm to the side. Compression will be needed if there are swelling and effusion, and this is effected by surrounding the joint with cotton, and covering the whole by a felt or hard-rubber shoulder-cap, which is firmly bandaged to the arm or shoulder.

Fixation should not be continued longer than there is subacute inflammation, and can be gradually discontinued; the bandage which holds the arm to the side being first discarded, and then later on the sling.

The question of the use of forcible passive motion in the convalescent stage is a vexed one. When the adhesions are chiefly periarticular, or confined to portions of the joints, and are firm, forcible motion under an anæsthetic will be necessary; but in the majority of slight cases gradual passive exercises will suffice.

If the fixation is due to muscular spasm chiefly, forcible passive motion will be of no use, as the spasm reflex to the inflammation at the joint will reappear, after the anæsthetic is withdrawn, as long as the disease of the joint remains.

Local applications are to be used at the shoulder-joint for the same reasons and indications as at other joints.

Ostitis.—In tuberculous ostitis at the shoulder-joint, the indications for treatment are practically the same as those present in chronic synovitis.

Distraction is not indicated in disease of the shoulder, as, owing to the laxity of the joint, the weight of the dependent arm, if kept at rest, is sufficient to separate the humerus from the opposing bone surface of the scapular articulation.

Abscesses are to be treated in the usual way.

In the severest cases, excision of the shoulder is indicated, and excellent results are attained.

ACROMIO-CLAVICULAR AND STERNO-CLAVICULAR ARTICULATIONS.—Fixation and expectancy are all that can be done for these joints. Fixation can readily be secured by retaining the arm, as in disease of the shoulder-joint.

ELBOW-JOINT.—Synovitis of the elbow-joint recovers usually under fixation, which is readily obtained by fixation splints, internal angular splints, external angular splints, or a lateral splint to which the arm is strapped or bandaged. These splints can be made of tin or pasteboard, reinforced with iron or wire (telegraph wire), or wood, and should be fitted to the arm bent to a right angle. Compression can be effected by surrounding the joint with cotton and bandaging it with an elastic rubber bandage. In time fixation by splints can be discontinued, and the support of a sling alone be relied on, with passive exercises and massage. In cases of ostitis the treatment is the same, except that a much greater length of time is required, and abscesses needing to be incised may supervene.

In the severest cases, excision offers the readiest chance of cure.

WRIST.—The treatment of disease of the wrist-joint is to be conducted on the same principles as that of the other joints, and consists chiefly of fixation, by means of palmar splints, and compression. It may be mentioned, in regard to tuberculous ostitis of the wrist, that excision, till recently rejected as an unjustifiable procedure, is of more assistance than has hitherto been supposed. It is, of course, indicated only in the severest cases. Excellent results have been obtained by this procedure, chiefly in adolescents and young adults.

OTHER JOINTS.—Diseases of the sacro-iliac articulation, and of the temporo-maxillary articulation, are treated elsewhere in this work (see under *Sacro-Iliac Disease*, and *Jaws, etc.*) The treatment of the remaining joints requires no especial mention.

Edward W. Bradford.
Robert W. Lovett.

JOINTS, INJURIES TO.—The injuries from which joints suffer are dislocations, sprains, concussions, and wounds. Dislocations are considered elsewhere; the other injuries are the subjects of this article.

SPRAINS (Distortions).—A sprain is a severe wrenching of a joint followed by stretching or tearing of one or more of its ligaments with effusion of serum or blood into the joint cavity, the extra-articular tissues, or both. They are caused as a rule by the same sort of violence, though in lesser degree, as that which produces dislocations; that is, by forced movements carried beyond their physiological limits, or by movements at variance with the normal mechanism of the joint (Tillmans).

Sprains are most common in early and middle life, and they occur frequently in joints that have previously suffered from sprain, in persons with undeveloped muscles, relaxed ligaments, or deformed limbs. Sprains of the ankle-joint and wrist-joint are most common owing to the relation which these joints bear to locomotion and prehension; the articulations of the foot, especially the calcaneo-astragaloid and the medio-tarsal, and the metacarpo-phalangeal joints also suffer frequently and for the same reason. The knee is sprained much less frequently than would be supposed from its relation to locomotion and the weight of the body, and the *enarthrodia*, owing to their wide range of motion and the strong muscles surrounding them, seldom suffer from sprains.

Pathology.—Sprains are of all degrees of severity from the trifling wrench, the effects of which quickly disappear, to the violence sufficient to produce a fracture or dislocation. A sprain is, in fact, a dislocation of greater or lesser degree in which the bones have returned at once to their normal relation. In severe cases, the ligaments, being inelastic, give way and are partially or completely divided or are detached from their insertions; the tendinous sheaths and contiguous muscles are often torn, sometimes at a considerable distance from the articulation, and tendons are frequently displaced or severed from their insertions. The blood-vessels in and around the joint may be ruptured, causing the joint cavity or the surrounding tissues to be filled with blood. The line of displacement in sprains usually takes the direction in which there is normally least motion; in the hinge joints it is, therefore, lateral. Through this unnatural motion, the synovial membrane is unfolded on one side, on the other it is compressed, crushed, and often torn (Sajous' "Annual"). The ends of the bones are contused and sometimes fractured. Common examples of the latter are found in the lower end of the fibula, the internal malleolus, and the lower end of the radius. To this the term *sprain fracture* is applied by some; others limiting the application of this term to those cases in which a ligament or tendon carries away a portion of the cortex of the bone to which it was attached. A fracture of the lower end of the external malleolus, complicating a sprain of the ankle, may be unrecognized and may serve to explain many cases of ankylosis following an apparently simple sprain of this joint (Callender). The articular cartilages are bruised, broken, or detached. The reactionary inflammation which affects these tissues, the increase in synovial fluid, the œdema of the soft structures, and the ecchymosis need only be mentioned.

Symptoms.—The first symptom is instantaneous and usually severe *pain* in the joint, accompanied by an impairment or total loss of function. The pain is characteristic of injury to ligaments, which are not sensitive to cutting, but react quickly to twisting, etc., a condition which may serve to protect articulations. Nausea and vomiting are often present even in sprains of minor degree. Swelling, due to extravasation of blood into the joint or periarticular tissues, and most noticeable where there is least resistance from ligaments, rapidly follows, obliterating the normal outlines of the joint. In mild cases the swelling may at first be very slight; it is often increased, however, by a subsequent synovitis. Evidences of inflammation soon supervene. Pain and tenderness continue, and after a few days indistinct crepitation may be noticed on movement of the joint, caused by a deposit of plastic matter in the contiguous soft tissue, the tendinous sheaths, or the articular cartilages. Pain and weakness may persist for a long time even after other inflammatory symptoms have apparently subsided; they result usually from incomplete union of the torn capsule, from overdistention of the capsule by synovitis, or from adhesions. Ecchymosis, due to extravasation into the soft parts, appears quite early; when due to blood in the joint cavity, it appears much later. Acute suppuration in a sprained joint is rare, unless the patient's general condition is greatly depressed. In slight sprains the pain and swelling quickly subside and the functions of the joint are soon restored; in severe ones, with involvement of the bones, cartilages, or contiguous structures, inflammation is increased and convalescence correspondingly delayed. Stiffness of the joint often persists after the inflammatory symptoms have subsided and sometimes there follow rigidity and wasting of the muscles.

Diagnosis.—As a rule the diagnosis is easily made. The gap in a torn ligament, especially a lateral one, may be seen and felt; and by the sense of touch a complicating fracture is usually detected with ease. Marked swelling often obscures the bony landmarks around a joint, and in such cases firm and continued pressure over these prominences will, by displacing the fluids in the infiltrated tissues, determine their situation; should they correspond in location and mobility to the sound side, the question of fracture or dislocation may be dismissed. The swelling may be so great, however, that a complicating fracture may be difficult of detection, and when the fracture is incomplete or impacted a diagnosis is impossible. In this case the Roentgen ray is of great aid in diagnosis and should, when available, always be used; when it is not possible to employ the x-ray an anæsthetic should be administered. Epiphyseal separations in children resemble sprains closely and for their differentiation the x-ray or an anæsthetic is required.

Treatment.—The treatment of course varies with the extent of the injury, but there are certain indications common to all cases, the most important of which are the following: (1) check extravasation; (2) prevent and subdue inflammation; (3) relieve pain; (4) promote absorption; (5) obtain repair of the torn ligaments; (6) restore the function of the joint.

Slight sprains need little treatment but a vast amount of care; indeed it is the slight, unheeded, and therefore untreated sprains that are most frequently followed by structural changes in the joint. Following a mild sprain the joint should at once be immobilized by a suitable splint or bandage and cold should be employed by means of the ice bag or Leiter's coil. Cold checks extravasation better than heat, which in the early stages tends rather to increase the bleeding; it also prevents inflammation, controls pain, and gives great comfort to the patient. To promote absorption and restore the function of the joint there is nothing as good as massage, which should be begun on the second or third day. It may at first cause pain, in which case only gentle stroking should be employed, beginning not over the tender and swollen joint, but on the healthy tissues above and below, and stroking in the direction of the returning lymph currents. During manipulation the limb should be kept in the most comfortable position and the greatest extent of the palmar surface of the hand should be applied. The first application should last for from ten to fifteen minutes, and kneading or passive motion, if painful, should not be employed. After massage return to the splint and cold for another twenty-four hours; then repeat the massage, keeping it up for at least half an hour (Cheyne). From this time onward the splint and cold may be discontinued; instead, pressure by means of cotton and an elastic or flannel bandage may be applied in the intervals between two successive massagings, which should be employed as often as once or twice a day. Passive motion may be begun with the massage as soon as the comfort of the patient will permit. When an articulation of the lower extremity is involved, the patient should go to bed; when the upper extremity is implicated, the limb should be held in a sling.

Severe Sprains are governed in their treatment by the same general indications. Immobilization should be secured at once and continued for several days, depending on the severity of the case. Immobilization for more than a few days, as under the older methods, is objectionable because adhesions are apt to form, thus causing impairment of function, and because, when there is a tuberculous taint, proper conditions for a localized tuberculosis are established (Mumford). Adequate fixation of the joint may be secured by encasing it in cotton beneath a plaster-of-Paris, silicate of soda, or starch splint, the patient remaining in bed if the lower limb is involved or wearing a sling if the upper extremity is injured. To limit effusion and control the pain cold should be applied. For promoting absorption and restoring joint function massage is the most effective agent. The proper time to begin its application cannot be arbitrarily laid down. Lovett believes that severe cases should receive absolute fixation and rest for a few days, when there may be substituted an adjustable splint which can be removed every day and thus enable the surgeon to note the progress of the case. With the subsidence of acute symptoms massage should be begun, and it should be continued thereafter once or twice every day. In the intervals between the sittings, pressure by means of cotton and the adjustable splint, later by an elastic or flannel bandage,

may be applied. Alternating hot and cold douches lasting for a few moments will heighten the effect of the massage. *Passive motion* should be begun as soon as possible, but not until after it ceases to provoke pain; it should be practised with gentleness and care, the range being gradually increased and pains taken not to strain an injured ligament. Under this treatment a period of two or three weeks often suffices to put a joint, suffering from a sprain of average severity, in condition for careful use (Mumford). Treatment should be continued for three weeks more, however, and an elastic bandage may be worn with comfort and increased security for a further period of six weeks (Cheyne). The time to begin walking or using the joint, like the beginning of massage or passive motion, cannot be arbitrarily stated. It should be attempted with great care, and the trials should be made at frequent intervals but for very short periods of time. As the pain caused by these efforts diminishes, the use of the affected part may be increased.

When a *ligament has been torn* across, the case must be treated with increased caution. A splint specially designed to support the injured ligament should be applied and kept in position for about six weeks; this length of time being necessary for ligamentous repair. To prevent the formation of adhesions, massage and passive motion should be employed with great care, so as not to disturb the injured ligament. When a ligament has been torn from its insertion, or has carried away a cortical fragment of bone, the same treatment is applicable.

A large effusion of blood into the joint cavity indicates a severe injury, one liable to be followed by synovitis and perhaps by adhesions and ankylosis. If the effusion keeps on increasing after the first day, or fails to be readily absorbed, it should be aspirated under the strictest aseptic precautions. Afterward the treatment follows the usual course. "In these more severe cases three weeks' rest or more should be insisted on before the joint is allowed to be used" (Cheyne).

The patient should be given a light and properly selected diet, and his bowels should be made to act with regularity. In severe cases in which the pain has not been controlled by rest and cold, internal anodynes should be administered.

Strapping (Fig. 3045), a method of treatment particularly suited to sprains of the ankle and tarsal joints, was first recommended by Cotterell and Gibney. The latter describes the method substantially as follows: Ordinary rubber adhesive plaster is cut into strips one inch wide, and of two lengths, respectively twelve and eighteen inches. If the patient is seen early and before the swelling is marked, the joint may be strapped at once. After the examination is made, massage should be employed for five minutes, the foot being elevated and relaxed. Then, the foot and lower leg having been shaven, the first, a horizontal strip, is applied, in such a manner as to lie parallel with and just above the border of the sole, its extremities ending just behind the great and little toes respectively. The second, a vertical, strip is next applied; it should begin a short distance above the ankle on the side least injured and should end half-way up the leg on the side of greatest injury, where the ligaments need and therefore receive the greatest support. This second strip crosses the first at right angles, and lies parallel with the tendo Achillis. Then horizontal and vertical strips, each overlapping its predecessor one-half, are alternately applied; the vertical ones coming gradually forward, the horizontal rising, until the whole ankle is enclosed, leaving out the point of the heel and a strip on the front of the leg and the dorsum of the foot, a precaution which prevents circular constriction and strangulation. The strips are all drawn tightly, and just beneath the malleoli the horizontal ones are reinforced by being doubled. A gauze or flannel bandage placed over the strips will cause them to adhere tightly and will further strengthen and secure the articulation. The patient should put on his boot and stocking and begin to walk at once; indeed, he may walk rather freely, provided it causes no pain whatever or only a small amount. A cane usually affords sufficient aid, and crutches as a rule should not be allowed, because the patient, depending on them, does not give sufficient motion to the injured joint. The foot should be flexed to slightly less than a right angle while the straps are being applied; this position is comfortable and permits the wearing of a low-heeled boot. The dressing should be removed and reapplied at the end of a week, and two or three dressings usually effect a cure.

Fig. 3045.—Cotterell and Gibney's Method of Strapping for Sprain of Ankle.

Gibney condemns the routine use of fomentations, plaster of Paris, and bandages. Strapping is applicable to both early and late stages of sprains, serving to fix the joint and limit effusion in the former, to fix the joint and promote absorption in the latter. In severe cases, complicated with fracture, blebs, etc., the application of strapping would of necessity be delayed for a few days, and even in the severe though uncomplicated cases, seen late, with much swelling, it might perhaps be better first to reduce the swelling by immobilization, elastic bandaging, and elevation. Under the treatment by strapping, patients are able to attend to business and the function of the part is completely restored much earlier than by other methods. It is applicable to other joints than the ankle. When both lateral ligaments have suffered equally, the vertical strips may begin and end at the same level. In severe cases, in which the swelling of the foot and toes is great and the whole ankle must be strapped, leaving no portion uncovered, it is necessary carefully to strap each toe.

Static electricity and *superheated air* are also advocated in the treatment of acute sprains.

Sequelæ and Prognosis.—Obstinate neuralgic pains, paroxysmal or continuous, and usually exaggerated by barometric changes, not infrequently follow a sprain. To relieve them, when all other methods have failed, it may be necessary to cut the nerve filaments supplying the joint. Stiffness more or less marked may persist for a longer or shorter period, but it usually yields to the treatment already advised. In rare instances, a joint may suffer at intervals of weeks or even months from attacks of acute or subacute inflammation, a condition referred to as "irritable joint." Counter-irritation, with immobilization, commonly affects a speedy cure. The prognosis will depend on the joint involved, the extent of the injury, the habit and physical condition of the patient, and the promptness and efficiency of the treatment. In the gouty and rheumatic, the joint inflammation is

generally tedious and chronic, yielding only to local, combined with constitutional treatment (with iodides, colchicum, etc.); while in scrofulous patients chronic osteitis, synovitis, or extensive destructive (tuberculous) disease of the joint may follow. Extensive hemorrhage into the joint cavity renders the prognosis more grave.

Ankylosis of a varying degree will follow in a certain number of cases; for its relief passive motion and massage combined with the use of superheated air may be employed. For the relief of the so-called false ankylosis, particularly that following traumatism, Gwyer strongly recommends the use of static electricity; but that it is as valuable as the measures referred to above is extremely doubtful. When the adhesions are very strong it may be necessary to "break them up" under an anæsthetic (*brisement forcé*), after which the case must be treated as one of acute sprain—that is, by cold, massage, and passive motion; otherwise the adhesions will reform. It may indeed be necessary, in making the necessary passive motion, to administer an anæsthetic several times. When wasting of the muscles has occurred, faradism should be employed. Finally it may happen, despite all possible caution, that the joint remains weak and troublesome for a lifetime, ankylosis may persist, or destructive joint changes develop, causing great suffering, from which patients are relieved only by excision or amputation. When ankylosis is imminent, the position of the limb should be such as to make it as useful as possible after stiffness is complete.

CONTUSIONS result from falls or from blows with a blunt instrument. They may be divided into *direct* and *indirect;* the former are produced by violence acting directly on the joint; the latter by *contre-coup.*

Indirect contusions are often spoken of as concussions; those of the hip, for example, are caused by a fall on the foot or trochanter. The principal injury in this variety of contusion is found in the articular cartilages which have been more or less bruised. The other structures of the joint may be injured, however, and sometimes there results an impacted fracture.

Direct contusions are, of course, closely allied to contused wounds of joints (see contused wounds), the difference being largely one of degree. Here the chief injury is to the periarticular soft structures and the synovial membrane. In slight contusions there may be nothing more than a bruising of the periarticular tissues, with perhaps slight extravasation of blood. Severe contusions, on the other hand, may be associated with laceration of ligaments or synovial membrane, chipping or detachment of the cartilages, injury to the ends of the bone, fracture or dislocation, and an effusion of blood into the joint.

Symptoms.—Besides the local evidences of contusion there will be an effusion of blood into the joint, sometimes so marked as to make the joint tense. In the latter instance flexion of the joint occurs, because in this position the limb is most comfortable and the joint has the greatest capacity. Infiltration of the skin and an ecchymosis appearing early if the contusion is direct, much later if indirect, will be observed. Pain and disturbance of function will vary in proportion to the degree of injury inflicted.

The *diagnosis* will depend on the history and signs of a trauma of the joint, on the subsequent swelling from effusion into the joint, and on the pain, tenderness, and loss of function. When there is a suspicion of injury to the bones or cartilages, an anæsthetic should be administered, and in every case the *x*-ray will give valuable aid. The possibility of hæmophilia or scurvy having produced the effusion must be kept in mind.

In a healthy subject, the recovery from a slight contusion is usually rapid and complete; but if the subject is delicate or tuberculous, there may result tuberculous disease, or abscess of the joint, or the bones may necrose or a sarcoma develop. A non-tuberculous abscess is rare; it may result from infection in the superficial tissue and subsequent extension to the deeper parts and to the articulation, or it may be due to infection of the effused blood by germs carried by the circulation. Tuberculosis of the joint is a much more common event. In the aged a contusion may result in a chronic arthritis with roughening of the cartilages, in calcareous deposits, or in absorption of the articular ends with shortening and loss of function. In severe contusions, associated with laceration of ligaments and synovial membrane, and characterized by effusion into the joint, the injury, if carefully treated, may result in absorption of the effusion and complete restoration; but often there is left behind a mass of fibrous tissue which interferes with motion and causes more or less ankylosis. If the articular cartilages have become detached and absorbed, the ankylosis may and likely will be bony. Severe contusions may also be followed by gangrene of the skin and subcutaneous tissues, or suppuration may develop in the joint.

Treatment.—Both slight and severe contusions must be treated with the utmost care. Rest and the application of cold were formerly widely employed, but rest, if too prolonged, is now considered harmful, since it permits the organization of the effusion into connective tissue and thus favors the production of ankylosis. Ice should be used only in the early stages to control the pain, and warmth may be more agreeable and quite as effective. The treatment of contusions is the same as that of sprains. Massage begun early, intermittent elastic bandaging, and passive motion, which promotes absorption, lessen the possibility of ankylosis and hasten recovery. The same rules govern the employment of massage in contusions as in sprains.

When the joint is overdistended by effusion, it may, under the strictest aseptic precautions, be aspirated; and when suppuration occurs, drainage and irrigation should be employed. A fracture complicating a contusion of joints must of course be treated by splints, but these should be removed every six or eight days (oftener in the later stages), and a new splint, changing the position of the joint, should be applied. Massage and passive motion should be employed when the splints are changed. If ankylosis is imminent, the limb should be placed in that position which is likely to make it most useful.

WOUNDS.—Wounds of joints are either non-penetrating or penetrating. The former are as a rule only serious when complicated by suppuration, which may subsequently invade the joint; they should be treated antiseptically, the parts being thoroughly immobilized. Penetrating wounds, on the other hand, are among the most serious of injuries, involving not only the usefulness of the limb, but often the life of the patient. They may be subdivided into: (1) incised, (2) punctured, (3) contused, (4) lacerated, and (5) gunshot.

Symptoms.—The symptoms vary according to the joint involved, the extent and nature of the injury, and whether or not infection has occurred. There are present, of course, the local evidences of a wound from which blood is escaping and usually synovial fluid. The latter may come from a bursa or tendinous sheath, but its escape in any quantity should be regarded as evidence of joint penetration; and since many of the larger bursæ are connected with the joint, it is well to assume that in every case in which there is an escape of synovial fluid the articular cavity has been invaded. When the wound is not too large and infection has not occurred, the borders of the wound soon adhere, the synovia ceases to flow, and the wound will heal without inflammation or permanent disturbance of the joint function; or a mild inflammation with a serous or sero-fibrinous synovitis may occur, but the symptoms soon subside. In infected cases the time at which the inflammatory symptoms appear will depend on whether infection has occurred at the time of the accident or later. In one group of cases the sides of the wound quickly unite, but on the third, fourth, or fifth day evidences of inflammation appear and rapidly increase; there are high fever and the constitutional symptoms of infection; the joint becomes tender, painful, and swollen, losing its normal outline; the skin becomes red and tense, and the site of the

wound is red, swollen, and even fluctuating. If the borders of the wound are separated, pus may appear. A second group of cases runs a more acute course, particularly those in which there is a large effusion of blood into the joint. In these the local and constitutional symptoms of suppuration appear within twenty-four hours, and unless the joint is freely opened and drained the results are most unfavorable; indeed, it may be necessary to resect in order to avoid the gangrene which may occur, accompanied by the constitutional evidences of sepsis. In still another group of cases the course is more subacute and the joint exudate, while large, is not strictly suppurative, but looks like cloudy synovia mixed with flakes containing pus cells. The most severe cases are those septic or gangrenous inflammations of the joint in which death occurs from septicæmia as early as on the fourth or fifth day (Tillmans).

Diagnosis.—In extensive wounds the diagnosis, as a rule, can be made by inspection, and the cartilages and other internal structures of the joint may be seen and felt. In punctured and small incised wounds the diagnosis is based on the history of the case, the character of the agent producing the wound, and the escape of synovial fluid. The agent producing the wound should, when possible, be examined to determine its physical properties, the probability of its having penetrated, and whether or not a piece may have broken from it and remained in the joint. The synovial fluid, as pointed out, may come from the joint, a tendinous sheath, or a bursa; if the last is one not connected with a joint, the fluid will escape only in small quantity. Probing to determine whether or not a wound has penetrated is allowable only under the most rigid aseptic precautions; even then it is conceivable that germs may be carried from the surface wound into the joint. Often the wound has already closed when the case is first seen, and one must await developments. At the first sign of inflammation, local or constitutional, an examination of the blood for leucocytosis should be made and some of the exudate in the joint should be drawn off, for purposes of examination, by means of a sterilized hypodermic needle.

Treatment.—All wounds of joints should invariably be treated with the strictest aseptic precautions. In a fresh case, if the wound is a small, incised, or punctured one, and the flow of synovia warrants the belief that septic influences have not as yet gained admission to the joint, then the wound and neighboring skin should be thoroughly cleansed in a strong antiseptic solution, a copious dressing should be applied, and the limb immobilized. Some surgeons recommend the immediate suturing of the wound under such circumstances, which course will be the more rapidly followed by repair; but it is evident that the wound should be closed only when it is certain that there is no infection. In the absence of this assurance, it is better to dust with iodoform and lightly pack the wound. When no infection has occurred, repair is rapid and the joint functions are not impaired. If, at a later date, the constitutional and local symptoms (fever with swelling of the joint and pain) warrant the belief that an acute suppurative inflammation has developed, then the joint cavity should be freely opened, carefully drained, and irrigated with a 1 : 2,000 bichloride solution. It should be dressed antiseptically, immobilized completely, and thereafter washed and redressed often enough to keep it clean; or else continuous irrigation may be established. Often this treatment is followed by a rapid abatement of the inflammatory symptoms and perfect mobility of the joint may be secured. If, when the patient is first seen, suppuration has already been established the same treatment may be adopted: that is, incision, drainage, which can scarcely be too free, and irrigation, either intermittent or continuous. In some cases, after incision, gauze packing may be employed. In certain cases, in spite of disinfection and drainage, severe constitutional disturbances occur. If the suppuration is so extensive that drainage of the joint presents great difficulties, then resection may be indicated; if systemic infection is threatened, it may be necessary to resort to amputation or disarticulation to remove the focus of infection (Tillmans). In extensive wounds which communicate with the cavity of the joint and leave little doubt that septic influences have gained admission, the joint should be irrigated thoroughly, foreign bodies should be removed, and the joint drained. The wound, if incised, should be loosely sewn, two rows of sutures being employed, a deep one of catgut which closes the rent in the synovial membrane, and a superficial one of suitable material closing the other structures. Contused and lacerated wounds should also be loosely sewn after their edges have been trimmed. When there is much laceration, however, and particularly when this is coupled with infection, it is well to pack the wounds. Cold, to lessen the inflammatory processes in a wounded joint, may be applied by placing ice bags outside of a wet antiseptic dressing, or an ice-cold antiseptic fluid may be used for continuous irrigation. When ankylosis is likely to follow, the position of the limb should be such as to make it most useful. Excision or amputation may be necessary when a wound is followed by disorganization of the joint structures.

Prognosis.—The gravity depends on the joint involved, the size and character of the wound, the age and condition of the patient, *but mostly upon the occurrence of infection.* Since the introduction of aseptic and antiseptic methods, the prognosis of penetrating joint wounds has improved greatly. When no infection has occurred, the cases usually run a very mild course and recover without any loss of function. Even in large wounds, if infection can be prevented, repair may take place without diminution of the usefulness of the joint. Even when suppuration has been established, the prognosis for life is good if the drainage and antisepsis are thorough, and in some cases the joint recovers its functions. As a rule, however, the joint is more or less damaged and the usual sequel of a continued suppuration is a more or less complete ankylosis. In certain cases death results in a few days from septicæmia; in others the course is more tedious, death resulting from pyæmia and exhaustion from prolonged suppuration and suffering; erysipelas and tetanus, though rare, are sometimes seen. "It should always be kept in mind that the risk is due not to the fact that an articulation is involved, but to the liability of infection and the difficulty, once infection has occurred, of preventing its spread."

Incised Wounds are caused by a sharp or cutting instrument. The character of these wounds is influenced by the condition of the cutting edge, by the cleanliness of the instrument, and by the size of the incision. They are less likely to be infected than the contused or lacerated varieties, and as a rule it is not only possible but advisable to close them by sutures.

Punctured Wounds are caused by the agents producing punctured wounds elsewhere; they are less dangerous, as a rule, than the lacerated, but more dangerous and more difficult of diagnosis than the incised. The severity of a punctured wound depends on the size and condition of the agent causing it and on the force expended. A small polished agent, free from septic matter, may cause little disturbance, but a blunt, rusty, or contaminated one is almost certain to be followed by inflammation. The diagnosis is rendered more difficult by the tendency of the punctured wound to close and shut off the escape of the synovia. Evidences of synovitis coming on in a few days would be almost certain evidence of contamination. When there is any question as to the character of the fluid in the joint, it should be withdrawn by a clean aspirator and examined.

Contused and Lacerated Wounds are usually caused by direct violence. They may be slight in degree, involving only the superficial tissue, or extensive, accompanied by compound fracture or dislocation and even by complete crushing and disorganization of the joint. Owing to their nature and the character and degree of violence producing them, these wounds are accompanied by symptoms of great gravity and by pronounced shock. In the non-penetrating wounds there is usually a certain amount of exudate in the joint, etc. Their treatment is, there-

fore, the treatment for lacerated and contused wounds elsewhere (antisepsis, suturing) plus the treatment for sprains (immobilization of the joint with elastic pressure, etc.). In the extensive and penetrating cases the shock must be carefully attended to, and until reaction is established the local treatment is antisepsis, control of hemorrhage, and immobilization. If there is a complicating dislocation or fracture, it should be attended to at once if possible. After reaction has taken place, an anæsthetic should be administered, the temporary dressings removed, and the joint cavity thoroughly washed out first with a 1 : 2,000 bichloride solution, and later with one of only 1 : 8,000, all foreign bodies being removed from the joint cavity or the soft tissues. Drainage tubes are then properly placed and the torn edges of the wound, having been trimmed to remove the devitalized portions, are closed by catgut; the whole is covered with gauze and immovably fixed. When laceration is so extensive that the wound edges cannot be apposed, it is better to pack the wound. Where laceration of the soft parts is extensive and complicated by crushing of the bones, it may be necessary to resect or even amputate.

Drainage of Special Joints.—The importance of thorough drainage of all suppurating cavities is emphasized in the case of joints which are drained with difficulty owing to their anatomical peculiarities. The same rules, however, govern here as elsewhere: namely, to drain at the most dependent portion and in accordance with the laws of gravity; in addition, care must be taken that all pockets of the joint cavity are effectively drained.

Fig. 3046.—Draining Knee-Joint in Slightly Flexed Position, with Drainage tubes in place.

The *knee*, the articulation most frequently in need of drainage, has a very extensive and irregular synovial membrane. The most dependent portions of its synovial cavity, in the recumbent posture, are the cup-shaped depressions in which the condyles of the femur rest. The synovial membrane also forms a short cul-de-sac beneath the quadriceps extensor tendon above the level of the patella. Still higher, reaching often to a finger's length above the patella when the leg is extended, is found a large synovial bursa which usually communicates with the joint cavity by a large opening, which may, however, be much constricted or entirely closed. There are other bursæ that may communicate with this joint: one beneath the outer, a second beneath the inner head of the gastrocnemius, and a third between the tendon of the popliteus and the outer condyle, but as a rule these are small, rarely involved in suppuration, and do not require separate drainage. Flexion of the knee relaxes the lateral and posterior ligaments, permits a slight separation of tibia and femur, draws down the synovial bursa beneath the quadriceps, also draws down the patella and applies it with more or less firmness, depending on the degree of flexion, to the articular surface of the femur, thus dividing practically the main cavity into two parts, a small one above the patella, communicating with the synovial bursa, and a larger one below and behind. Neither subdivision can during flexion be drained effectively by way of the other. Extension, on the other hand, brings the femur and tibia in close apposition, tightens all lateral and posterior ligaments, but relaxes the anterior structures, permitting the patella, the upper cul-de-sac of the synovial membrane, and the synovial bursa to recede farther up the anterior surface of the thigh.

The best drainage, then, can be obtained in the following way (Fig. 3046): Flex the leg slightly, permitting the hamstring tendons to recede backward and inward, thus uncovering the posterior aspects of the condyles of the femur; make an opening on either side of the patella into the joint cavity; through these openings carry a grooved director, or blunt-pointed scissors curved on the flat, backward beneath the corresponding lateral ligaments to the most dependent part of the condylar pouches; cut down upon the end of the director or scissors, making a free opening, and carry tubes from the anterior to the corresponding posterior openings; dress and fix the leg in the slightly flexed position by some form of splint. The most dependent point of the inner pouch is reached by passing the probe backward and obliquely upward; the outer one is reached, by passing it almost directly backward. The synovial bursa beneath the quadriceps always needs a separate drain, whether it communicates with the general joint cavity or not, except in those rare cases in which it is separate and *not* invaded by the suppuration. The lowest part of this bursa is on the outer side where it extends backward to the intermuscular septum attached to the external condyloid ridge. Here the drainage tube should be placed; it may be a single tube entering the bursa only, or crossing and emerging at the opposite side. When the bursa communicates with the joint cavity by a constricted opening, the latter may be dilated with benefit. In the extended position, the drainage tubes are squeezed by the lateral ligaments, or, if the tubes cross the joint cavity, by the bones; the posterior ligament being taut also interferes with drainage of the posterior pockets. When ankylosis is feared, however, one may be compelled to adopt the extended position; then one of the following methods, or some modification will serve the purpose: (*a*) In mild cases, incisions on both sides of the patella and short drainage tubes; in severe cases, the bursa beneath the quadriceps to be separately drained (Esmarch); (*b*) by carrying a tube into the joint to the inner side and opposite the lower part of the patella, backward through the intercondyloid notch and the popliteal space to the outer side of the vessels (this is the only situation in which a tube can traverse the joint without compression); (*c*) another method recently recommended is to locate short tubes at either side of the patella in front and a third one well back in the joint, crossing from side to side. The last is, however, impossible unless the joint has been disorganized by suppuration or injury. Glass tubes are recommended by Tillmans.

The *ankle* is best drained by through-and-through drainage placed at the posterior part of the joint. The *hip-joint* can be drained in front of or behind the great trochanter. The *shoulder-joint* is most superficial and can be most readily opened from in front, but in the recumbent posture a drain may be placed posteriorly, or through-and-through drainage may be established, great care being exercised to avoid wounding the circumflex nerve. The *phalangeal* joints should be drained on their dorsal surfaces, or at the side, owing to the location of the flexor tendons and their sheaths in front. The *wrist*, the *carpal*, and the *tarsal* articulations are compound, possessing more than one independent synovial membrane. They should, as a rule, be drained from their dorsal surfaces, great care being taken to avoid

opening a synovial cavity not involved in the suppuration. The location of wounds, or the point at which suppuration processes "point," may in some degree modify the location of a drain.

Gunshot Wounds of the Joints.—Gunshot injuries of joints are practically complicated wounds, exhibiting the peculiarities of the contused and lacerated varieties and often combined in severe cases with extensive compound comminution of the articular ends of the bones. When a rifle ball of the regulation size passes through a joint, the bony, cartilaginous, and ligamentous structures are more or less disorganized and even the contiguous vessels and nerves may be seriously injured or destroyed. Modern projectiles, made wholly of or covered by steel, of small calibre and great velocity, are liable to pass clear through a joint, leaving only a small tubular wound. Because they are small, smooth, and hard, they retain their shape and are not likely to carry in pieces of clothing or leave fragments of themselves in the wound. Leaden bullets change their shape, become deflected, and, at short range particularly, are likely to break into several pieces, some of which may remain in the wound; for these reasons the leaden bullets take more devious courses, produce relatively more comminution, and are more liable to carry infection. The wounds found in civil practice are, as a rule, made by small hand fire-arms (pistols, revolvers, etc.) carrying usually the leaden bullets of small calibre; these wounds are generally small and not accompanied by extensive comminution. If the missile is "spent" or propelled by insufficient force, it may produce a contusion only, or it may lodge in the joint cavity, or become more or less deeply embedded in the articular end of one of the bones.

Gunshot wounds may be extra- or intra-articular. The former involve the soft tissues over the joint and are only serious because of the possibility of a suppuration extending and involving the articular cavities. Intra-articular wounds open the capsule and are generally accompanied by injury of the bone, cartilage, and synovial membrane.

The course and effect of bullets are of great variety, but, for practical purposes, it may be assumed that a bullet has taken one of the following routes: (1) It may have passed through the cavity of the joint without injury to its bony or cartilaginous structures; (2) it may have entered the joint and remained loose in the cavity; (3) it may have entered the joint cavity and become embedded more or less completely in the head of a bone; (4) it may have passed through or remained in the joint after having fractured the bone; (5) it may have passed through the bone without having fractured it—tubular wound of bone;—(6) it may have caused a more or less extensive comminution of bone structure; and, finally (7), it may have destroyed the vascular or nervous supply to the limb below the point of injury.

Symptoms.—Shock is sometimes severe, particularly when there is extensive comminution; in many cases, however, it is absent or very mild. The pain as a rule is not great. Locally, there will be noticed the opening or openings caused by the bullet, from which there escape blood and synovial fluid. There will also be distention of the joint with blood (hæmarthros) or serum, loss of function, and crepitus, and the presence of bony fragments may be detected by manipulation. The escape of synovial fluid may, of course, come from a wounded bursa.

The *diagnosis* must be largely based on the symptoms. Probing to locate the ball should, as a rule, not be attempted, or it should be employed only under the strictest aseptic precautions. The porcelain-tipped probe of Nélaton, the electric probe of Graham Bell, the "telephone" probe of Girdner are all valuable aids, but the Roentgen ray furnishes the safest and most scientific method of locating a bullet or diagnosing a complicating fracture. A count of the white blood corpuscles may help to decide the question of beginning suppuration even before the other symptoms warrant opening the joint.

Treatment.—Severe shock must be treated by stimulants, etc., and if the loss of blood has been great, it may be necessary to resort to venous or subcutaneous transfusion of salines (see *Shock*). The local operative treatment must be carried out under the strictest rules of asepsis. Great laceration of the soft parts, extensive comminution of bone, injury to the main vessels or nerves, combined or separately, demand amputation as a rule. Amputation, when the vascular supply is sufficient to prevent the death of the parts and the nervous supply ample to provide for the continuation of one or more functions of the limb, may often be delayed, at least for a short period of time. Less extensive injuries than those described may demand an atypical resection at once or at some time in the future.

At the present time, even quite extensive gunshot injuries of joints are treated by the expectant plan, which means: (1) rigid antisepsis; (2) the removal of loose fragments of bone and the bullet, particularly if the latter is easily found, is free in the joint cavity, or is so superficially embedded in the bone as to interfere with joint motion; (3) the introduction of drainage and irrigation of the joint; (4) the application of an antiseptic dressing; and (5) fixation of the limb by some form of splint. This is practically the treatment of a lacerated wound. Should the wound pursue a favorable course, we may hope for recovery with more or less impairment of the joint and possibly with complete ankylosis; if suppuration occurs and continues, amputation or excision may be performed later. In anticipation of the possibility of ankylosis, the limb should be kept in the position in which it would be most useful.

The gunshot wounds seen in civil, as well as many of those observed in modern military practice, are small and not accompanied by extensive comminution of bone. The *expectant treatment* as applied to them consists of sterilizing the wound superficially and the skin in its neighborhood, applying a copious antiseptic dressing, fixing the joint by a plaster-of-Paris or some other form of splint, and waiting. If no infection occurs, the splint may be removed after a few weeks and massage with passive motion begun. Infection, as evidenced by pain, rising temperature, increased leucocytes, etc., will demand the removal of the splint and the exploration and drainage of the joint. Hidden hemorrhage, a reasonable certainty of infection, etc., make it necessary even in these small wounds to explore at once, draining and irrigating the joint.

Complications and Prognosis.—A shot wound of a joint, however trivial it may appear, is never without danger. Pyæmia and septicæmia are the most common and fatal complications, and erysipelas and secondary hemorrhage claim their share of victims. The more extensive the injury done to the bone, especially the cancellous tissue, the greater the danger from blood poisoning. Thorough attention to the details of antisepsis and good drainage have already reduced, and will still further reduce, the frequency of septic complications. Ankylosis, caries, and necrosis are also common sequelæ of gunshot wounds.

George D. Stewart.

JOINTS, MOVABLE BODIES AND DEFECTIVE CARTILAGES IN.—I. Movable Bodies.—The expression "joint derangement" is yet sometimes applied to the manifestations attendant on either of the conditions named in the title of this article and to such other enigmatical phenomena as not infrequently are witnessed in articulations. We are disposed to regard this expression as an antique form of words illustrative of a deficient knowledge of the special causes giving rise to the manifestations prompting its use. Later knowledge is narrowing its limits, and soon, we believe, will banish the phrase from surgical writings. The so-called derangement is due not only to the direct result of injury and disease of the component parts of the articulation, but also not infrequently to the presence, in joints, of the products of various histological processes that unaccountably happen elsewhere in the body in tissues similar to those of joints. The existence in a joint of a movable body was first recognized by Ambrose Paré in 1558, who then de-

scribed the removal from the knee-joint of such a body by himself. One hundred and thirty-three years later Pechlin duplicated Paré's experience. In 1726 Monro, and ten years later Simpson, both removed from the knee a movable body, only that of the latter being from the joint of a living subject. During the last one hundred and sixty years extended consideration has been given to the topic by nearly all prominent surgical writers, notably Hunter, Nélaton, Velpeau, Brodie, Rokitansky, and others, not to omit König whose modern contention regarding his own belief of their nature has done much indeed to foster investigation and hasten etiological conclusions regarding them. It appears that all freely movable articulations are subject to this infliction, that the knee-joint suffers oftenest, the elbow next in frequency, and that the ankle, shoulder, temporo-maxillary, and carpal joints, all comparatively rarely exhibit this infirmity. The number and size of these bodies are variable. Magendie found 25 in a knee-joint, Haller 20 in a temporo-maxillary, Malgaigne 63 in a shoulder-joint. Dr. James Berry reports (1894) the case of a man twenty-two years of age, from the knee of whom 1,047 loose bodies were removed. They vary in size from that of a mustard seed to that of a patella and of the astragalus. The structure of these bodies differs and is variously described by different writers, suggesting a difference of origin and development and possibly also a difference in the degree of care exercised in observation. Some of the growths are characterized as fibrous, others as tough and striated, of ligamentous texture and hard like stone. In the majority of instances they are said to be fibrocartilaginous, and, if ancient, possessing a central bony structure. Bolton (1896) reported 72 cases from various sources which he examined and classified according to structure with great care, as follows: Cartilage 20 cases, cartilage and bone 9, articular cartilage 6, fibrocartilage 5, fibrous bodies 5, bone 20. The remaining specified 9 instances comprised 4 of lipoma arborescens, 2 of which were associated with tuberculosis, 1 each of tuberculous tissue, hypertrophied fringe and sarcoma, and 2 of blood clot in fringe. In 16 the structure was not stated. Barth (1898) reports 55 cases, all containing cartilage, some partly composed of spongy bone. They are variously shaped, being oval, lenticular, round, in fact, of devious outlines apparently modified in part by their articular environment; as, for instance, in the knee-joint they are usually compressed and wedge-shaped, perhaps raised on one side and hollowed on the other; in some cases resembling in outline the patella, in others angular with facets. These bodies may be detached and freely movable or tethered and consequently of limited movement. Of Bolton's 72 cases 23 were pedunculated, 49 non-pedunculated.

The *etiology* of these bodies is as yet not fully settled. Whether or not they are the direct or indirect products of traumatism or are independent of it, their presence being disclosed by the special attention directed to the injured joints, are open matters of discussion. Hunter regarded their origin as dependent on coagulated blood in the joint cavity, therefore practically of traumatic inception. Velpeau concurred in this idea. The museum at St. Thomas Hospital contains several examples of movable bodies in joints, the character of which bodies sustains the preceding idea of their causation. Movable bodies are found in joints afflicted with rheumatoid arthritis. Then they are found both outside and inside of joints, and in the latter instance are thought to gain access thereto by means of external pressure pushing them against the synovial membrane, finally causing the membrane completely to surround the intruding body. Brodie believed that in the majority of such instances as the last stated, the body was primarily developed in the synovial structure and later gained access to the joints in the manner just stated. Laënnec, Béclard, and Cruveilhier concurred in their belief, and the latter illustrated cases demonstrating their presence in, and external to, the synovial membrane attended with free and attached loose bodies in a joint, each covered with synovial membrane, the attached bodies being tethered by slim pedicles composed of synovial membrane itself. König (1887) expressed the belief that these bodies seldom were the result of injury of a healthy joint, but rather were the result of disease of bone or cartilage supplemented occasionally perhaps by severe traumatism. This distinguished surgeon reported (1899) 70 cases happening during the preceding twenty years, 36 of which were due to osteochondritis. Barth, Vollbrecht, and others opposed König's views. Barth asserted that slight traumatisms could produce the conditions necessary to the presence of these bodies, and that they were either of traumatic or of arthritic origin. Vollbrecht (1898) determined, from careful examination, for a period of ten years, of clinical and army subjects, that quite sixty-five per cent. of the cases had histories of trauma. Weir called attention (1892) to an interesting condition causing joint derangement of the knee, which simulated in all essential respects the presence in this joint of a movable body. Exploration of the joint revealed the fact that a duplication of fibrous membrane extended from the under surface of the patella and the adjoining surface of the femur to such a length as to be caught between the articular surfaces during flexion, thus "locking" the joint, and also impeding extension. A grating sound beneath the patella attended the establishment of motion in the two cases of this disease which he had observed. Both were readily cured by removal of this obstructing agent. Others have noted a similar experience. In a recent unique case (1902) of the writer's, bearing on the structure of the obstructing body, Prof. Edward K. Dunham, after a most careful examination, expressed the following opinion: "The specimen is a piece of spongy bone covered with a thin layer of fibrous tissue. The outer shell of bone is thin and appears continuous except for a few foramina containing blood-vessels and a little adipose tissue. The fibrous covering is more highly cellular near the bone than at the free surface, and a layer of cells contiguous with the bone may be clearly seen in some places. This layer contains a few larger cells which are multinuclear and lie in small excavations in the bone. The interior of the specimen contains plates of bone which divide into branches that join to form spongy structure. The spaces between these bony plates contain fatty marrow supplied with blood-vessels in considerable numbers. The surfaces of the bone plates are covered with a layer of flattened cells. The bone is laminated, the strata being parallel to the surface, and it contains bone corpuscles regularly and typically arranged. Beneath the periosteal covering there are places where a few laminæ of bone appear to be younger than the rest, indicating bone production by the deeper layers of the periosteum. There are no indications of any recent or post-inflammatory process in any part of the specimen, and the sections are entirely free from cartilage." When it is considered that this specimen was nearly half an inch in diameter, and that if it originated in the injury which revealed its presence, it must have developed in less than three months, it is quite evident, in view of its complete bony structure and the absence of local inflammatory changes, that its inception antedated the injury, and that its presence was revealed by the scrutiny that followed the local effects of the traumatism. That synovial membrane and fringes which characterize the joint may become so elongated or otherwise changed as to be caught between the articular surfaces, is a matter not infrequently demonstrated by operative practice.

The *symptoms* attendant on the presence in a joint of one or more of these bodies are chiefly dependent on the structure and the use and mechanism of the joint; likewise on the fact whether or not the body be disconnected and freely movable or be connected to contiguous tissue by a long or short pedicle; and also upon its size and shape. The joint, whose structural mechanism permits of the widest articular separation, and those of the most varied movements and whose functional demands exact the support of burdens under varying degrees of movement, are the articulations that especially suffer from this form of infliction. The knee-joint, because of various causal re-

quirements, is practically the most frequently and variously involved in this respect of the joints of the human economy. The symptoms of movable bodies in joints, especially the knee joint, are readily recognized by those familiar with the language of this misfortune. An unusually abrupt, unexpected, and often excruciating pain at a definite aspect of the knee-joint, with sudden arrest of movement and fixation of the limb at the angle of attack (causing the patient—often suffering from nausea and faintness—to stand still or to lean against a convenient support until the acuteness of the pain lessens or is entirely relieved by a studied or fortuitous movement of the limb, thus releasing the offending body from the confinement causing the distress), is a familiar picture of this infliction. Usually at the time of attack the leg is being extended from the flexed position characteristic of walking upon a plane surface or ascending stairs. Rotation at the knee-joint before the foot is firmly planted sometimes causes an attack. This symptomatic picture is varied, as regards the characteristic features, in different cases and in repeated attacks, each being usually severer than the preceding, and followed by correspondingly increasing traumatic reaction, until finally the joint becomes permanently incapacitated. It is not always easy to determine the presence of a movable body in a joint especially when one is unable to feel the object with the fingers. And when its presence is determined by palpation the elusiveness of a freely movable body often defeats immediate efforts at removal. In such a case a patient should watch for a reappearance of the body, hold it in place when detected, and keep the joint quiet until competent assistance can be gained to effect removal. The piercing of the object with a needle the better to hold it in place can be commended when aseptically practised. If the object is free in a joint and not within the grasp, its detection and removal are matters requiring wise surgical discretion under these circumstances. It is not easy and sometimes is impossible to detect in the knee-joint a freely movable body, unless the large size—large enough, in fact, to prevent its hiding in one of no less than four marked synovial elongations of the joint, to say nothing of intercondyloid and interarticular fibrocartilage infoldings of the membrane—favors the effort. The free opening of the joint for the purpose of detecting and removing a supposed movable body should not be heedlessly undertaken, since the contingencies incident to the act may be of far greater import to all concerned than operative inactivity. Operative exploration ought not to be made until one is assured of the presence of an offending body by manipulative examination or until it becomes plain that the repeated attacks are exposing the patient to dangers which are quite as serious as those of the explorative operation itself.

The operation consists in making a free and usually vertical incision down upon the foreign body, under the strictest aseptic measures, supplemented with rubber coverings for the fingers. Then, after the body has been removed, the wound should be flushed with saline solution, the opening in the synovial membrane should be closed with interrupted sutures of fine chromicized catgut and the external wound with interrupted sutures of silkworm gut. Finally, the parts should be enveloped with aseptic dressings, and the joint kept immobilized for several days. Then, when the dressings are removed, complete union will usually be found to have taken place, and ultimately a perfect cure may be looked for. All needless exploration of the parts should be avoided.

The results of operation both before and subsequent to antiseptic technique are practically shown by the tabulated statement of Dr. J. P. Tuttle:

	Cases.	Cured. Per cent.	Failures. Per cent.	Mortality. Per cent.
Baumdorf	216	66.2	18.99	14.81
Lowy (1860)	167	68.86	19.26	11.38
Browne (1884)	88	82.95	5.68	14.38
Tuttle (1896)	107	97.19	2.81	....

II. Defective Cartilages.—"Displaced cartilage," "slipped cartilage," "subluxation," and "internal derangement" are expressions of practically synonymous application and self-evidently refer to some form of modification of function and arrangement of the semilunar cartilages of the knee-joint. The injuries and diseases characteristic of these joint structures constitute important items of affliction incident to the life history of joints thus provided. The cartilages may be displaced, bruised, crushed, or torn, and the ligaments maintaining them in proper relationship with the articular surfaces and properly attuning their functional movements, may be stretched, bruised, or ruptured. The inner side of the semilunar cartilage of the knee-joint and its attachments suffers more frequently than does the outer side of similar structures. Bennett (1900) reports 155 instances of inner-side attacks against 45 outer-side. Of this number 182 were males and 18 females, and the ages of the patients varied from thirteen years to sixty-two years. The exact reasons for the greater frequency of inner-side involvement are somewhat problematical. It may be accounted for by the fact of the greater degree of functional activity that is present during motion at this portion of the joint; for the internal semilunar cartilage moves over a greater area of articular surface than the outer, in order to meet its functional requirement. Also greater weight is received on the inner condyle than on the outer, and, too, it is more exposed to external violence than is the former. Functional derangement of these cartilages, resulting in their becoming pinched between the moving articular surfaces, is predisposed by any roughening that hinders the harmony of action necessary for the proper performance of the advancing and retiring movements imposed on them during activity of the articular surfaces between which they are placed. And should this condition be present together with relaxed ligamentous attachments of the cartilages, then will the danger of pinching be increased, and even actual displacement be threatened. Especially is this true of the inner cartilage during actual extension with supination of the leg. In their normal state these cartilages cannot be broken, although they may be bruised, torn, and twisted. If, however, they have become hardened by morbid processes, it is not impossible that they may be displaced or broken by severe circumscribed violence directed from without. They may be broken, or their coronary attachments may be ruptured under these circumstances by violence, while the weight of the body is borne on the extended limb, but they cannot then be displaced. Violence directed against the outer border during the act of flexion of the leg and thigh may cause it to be torn from its attachments and even ruptured, and then if extension follow quickly and forcibly, it may be overridden by the opposing articular surfaces, and thus held or be forced posteriorly upon the articular surface. If the joint be already impaired by ligamentous relaxation and other structural changes, then surely derangement and displacement of these so-called cartilaginous structures will much more readily take place. The common symptoms of that form of knee-joint infliction differ in no especially practical measure from those of movable bodies with which it is often confounded.

The special indications of semilunar involvement relate more especially to modifications of the normal contour of the joint surface at the site of the cartilages, as determined by palpation. In health, with the leg extended, the external rounded borders of these cartilages can be easily felt in the normal state, and it will be noticed that they will recede gradually from the touch as the limb is being flexed, causing instead a marked depression corresponding to their former site. If the cartilage be displaced outward, then undue prominence is noted at that point, which may or may not disappear with flexion of the limb. The semilunar cartilages may become displaced outward at other aspects of the joint, but in these instances their mobility is less influenced by the normal movements of the joint than in the first instance. If the displacement be inward toward the centre of the joint,

the degree of extension which may be attainable need not return the cartilage to its normal site, and therefore a depression is noted in lieu of the normal contour of the cartilage. If the coronary ligaments be ruptured, these cartilages will recede and advance perceptibly during flexion and extension of the leg, provided the articular surfaces and those of the adjacent cartilage are smooth and properly lubricated. If otherwise, they may be easily pinched and perhaps overridden during extension of the limb. One should judge of the nature and extent of the injury of a joint by carefully comparing its physical and functional characteristics with those of its uninjured fellow.

If the cartilage be displaced, its prompt reduction should be attempted. Various methods of procedure are advised for the accomplishment of this purpose. The chief element of a successful reduction is based on the fact that flexion of the leg relaxes the connecting structures of the joint in direct proportion to the degree of that act. Now, since relaxation loosens joint tension, it follows naturally that loosening of the tension favors the restoration of the displaced cartilage, either by its own inherent elasticity or by direct manipulation, in the best possible manner. For this reason various degrees of extent and rapidity of flexion, combined with supination and pronation of the leg, are advised for the purpose of reduction. The following, advised by Allingham, is sufficiently comprehensive to suggest, and probably even meets the demands incident to, displacement. "Flex the leg as much as possible on the thigh, drawing upon the tibia as if to separate the articular surfaces from the femur. Then rotate the tibia inward if the internal cartilage be displaced, and outward if the external cartilage be displaced. Both movements should be resorted to if the usual one does not succeed. Then extend the leg on the thigh quickly, but not with great violence, at the same time pressing with the thumb upon the projecting cartilage." After reduction, rest and immobility, until the danger of inflammation has subsided, will commonly suffice. It is noteworthy that not infrequently the severe pinching of the cartilage due to displacement is followed by such a degree of swelling and tenderness of the structure and deformity of limb as to give the impression after reduction that displacement is still present. If reduction fail of accomplishment, then either of two plans can be pursued:

1. The employment of massage and passive motion, after the symptoms incident to the injury have subsided. The use of elastic knee-caps, bandages, and perhaps even apparatus to limit movement may be needed. This course will in time restore the function of the joint, although at intervals derangements will ensue, the same as may happen even when the reduction is accomplished at first.

2. The exploration of the joint through a liberal perpendicular or oblique incision made into it at the site of the displaced structure, about three-fourths of an inch from the ligamentum patellæ. If the integrity of the cartilage will permit, it should be returned to its proper position, and be stitched there with fine aseptic silk or chromicized catgut. If this be not allowable, on account of the great extent to which its structure has been damaged, it should be removed entirely. In either instance, finally, the joint should be irrigated with an aseptic solution and closed by two rows of sutures—the first including only the synovial membrane and its closely adjacent connective tissues; the second, the remaining tissues of the wound. Either silk or catgut can be used, as best suits the wish of the operator. The employment of drainage will depend greatly on the extent of handling to which the structures of the joint cavity have been subjected. Ordinarily it need not be employed; still, the introduction into the joint of carbolized horsehair or silkworm gut, for drainage purposes, cannot in itself do harm, and should therefore be employed when indicated.

The alar cartilaginous structures of a joint may become so elongated or enlarged, as the result of disease, as to be pinched by the articular surfaces. Extravasations of blood within their folds may so change their relations with the joint surfaces as to cause pinching at once, or bring it on at some later date, on account of the formation of fibrinous bodies within them, which remain attached to the borders of these structures, or are eventually disconnected and wander freely in the cavity.

The result of operation for this condition is fairly represented by the statements already made in regard to the outcome of operative interference in the case of movable bodies. *Joseph D. Bryant.*

JORDAN'S WHITE SULPHUR SPRINGS.—Frederick County, Virginia.

Post-Office.—Jordan's Springs. New hotel.

Access.—Viâ Harper's Ferry and Staunton Branch of the Baltimore and Ohio Railroad to Stephenson's Depot, thence by stage two miles to springs.

This well-known summer resort is located in the northeastern part of the beautiful Shenandoah Valley, six and one-half miles from the city of Winchester. The elevation here is 1,200 feet above the sea-level. Charming scenery and delightful climatic conditions will be found. The hotel, just completed, is thoroughly modern and sanitary in all its appointments. A new bath-house affords all conveniences for bathing. The springs supply an abundance of water, having an unvarying temperature of 57° F., the year round. Like other sulphur waters, it is at first unpleasant to the taste, but a tolerance and even a liking for the water are quickly acquired. The following analysis was made in 1871 by Thomas Antesill, chemist of the United States Department of Agriculture:

One United States Gallon Contains:

Solids.	Grains.
Calcium sulphate	5.13
Potassium sulphate	2.09
Sodium chloride	.76
Potassium carbonate	9.71
Magnesium carbonate	2.88
Iron carbonate	Trace.
Manganese carbonate	.01
Hydrosulphuric acid	.79
Silicic acid	.25
Alumina	.01
Total	21.63

This water has been in use for many years. Its most marked properties are diuretic, aperient, and tonic. It is also believed to possess an alterative as well as a diaphoretic influence. The chief application of the water has been in cases of chronic diseases resulting from derangement of the liver, kidneys, stomach, and blood, and glandular system. It is said to be very beneficial in obstinate cases of gout and rheumatism. The water is sold by the barrel, half-barrel, demijohn, or bottle.

James K. Crook.

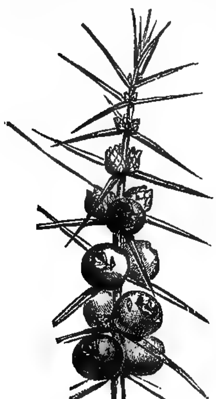
JUNIPER.—Juniperus. The fruit of *Juniperus communis* L. (fam. *Pinaceæ*). Juniper fruits are no longer official.

The common European juniper is of variable stature, sometimes attaining the dimensions of a small tree; more often it is a short, broad, pyramidal shrub, with spreading branches; sometimes it consists only of a large flat rosette, with its prostrate or slightly ascending branches lying on and rooting in the ground; by this habit, as well as by its slender, spreading, awl-shaped leaves in whorls of three, and by its larger and more juicy berries, it is easily distinguishable from the common juniper of this country (*J. virginiana* L.).

This shrub grows in nearly all parts of Europe, and is also widely distributed through Central and Northern Asia, as well as in the United States, either native or naturalized. The chief production of the fruit is in Hungary. The "berries" are in reality short fleshy cones, whose three upper scales have become soft and juicy, and coalesced over the three stony seeds; the rudiments of their scale tips may be seen near the top of the fruit. The lower scales are small, dry, and appressed to the axis or peduncle. The berries shrivel a good deal

in drying, and were described in the Pharmacopœia as follows:

"Nearly globular, about one-third of an inch (8 mm.) in diameter, dark purplish, with a bluish-gray bloom, a three-rayed furrow at the apex, internally pulpy, greenish-brown, containing three ovate, somewhat triangular, bony seeds, with several large oil glands on the surface; odor aromatic; taste sweet, terebinthinate, bitterish, and slightly acid."



L

O

FIG. 3047.—*L*, Juniper Branch, with Fruit attached. (Baillon.) *O*, Juniper fruit, separate. (Baillon.)

COMPOSITION.—The most important substance is the *essential oil*, of which they contain from one-half to one and a half per cent. There is also a large amount of sugar (up to twenty-five per cent. or more), and nearly half as much resin.

The oil consists chiefly of pinene, but its characteristic odor is due to an unknown substance. It is official, and is thus described in the Pharmacopœia:

"A colorless or faintly greenish-yellow liquid, becoming darker and thicker by age and exposure to air, having the characteristic odor of juniper, and a warm, aromatic, somewhat terebinthinate and bitterish taste.

"Specific gravity: 0.850 to 0.890 at 15° C. (59° F.).

"Soluble in about four times its volume of alcohol, forming a somewhat turbid liquid, which is neutral or slightly acid to litmus paper. Also soluble in an equal volume of carbon disulphide."

ACTION AND USE.—Juniper berries and oil have the properties of the terebinthinate substances in general. In small doses aromatic, stimulant to the stomach and intestines, hæmostatic; in large ones capable of producing gastritis, nephritis, strangury, etc., as well as nervous disturbances. The chief use is as a stimulating diuretic. A violet-like odor in the urine, and a copaiba-like erythema, are occasionally observed after its administration. Juniper berries are, or ought to be, used in making the *liqueur* called gin, which is alcohol distilled off from them and containing their oil. They are not much given by themselves in this country, but might be used as a stimulating diuretic; an infusion or the oil being used.

ADMINISTRATION.—From 4 to 8 gm. (ʒ i. to ij.) may be given at a dose. An infusion of the bruised berries extracts much of the oil, the sugar, etc., and is an acceptable form. The oil may also be given, but is much adulterated with harsher oils from the tops and leaves, and even with oil of turpentine. Dose, gtt. v.–x. There is also a simple five-per-cent. spirit of juniper, the dose of which is fl. ʒ ss. to i., but it is not much used; and a compound spirit, or artificial gin, offered as a more reliable aromatic than that liquor. Its composition is as follows: Oil of juniper, 8 parts; oil of caraway, 1 part; oil of fennel, 1 part; alcohol, 1,400 parts; water, to make 2,000 parts. Dose, fl. ʒ i.–iv.

ALLIED DRUGS.—Other important products of the genus Juniperus are *savin* and *cade oil*, elsewhere described, besides which there are a number of minor products, mostly oils distilled from the fresh twigs of various species of cedar. Since the properties of these differ in no important respects from those of oil of savin, they need not be further considered. *W. P. Bolles.*

KAIRINE.—The name *kairine* is in present use to designate, generically, certain artificially prepared derivates of chinoline, where either a *methyl* or an *ethyl* substitution has been effected in the chinoline molecule. Of the two kairines, the *methylated*, although the one first made and experimented with, has been superseded by the *ethylated* example, for the double reason that the latter is both easier and cheaper to make, while at the same time it is better as a medicine. The ethylated compound *kairine A.*, as it is technically called, is what is now commonly dispensed under the simple name *kairine*. The karaine in medicinal use appears as a whitish crystalline powder, without smell, but of a bitter and pungent, slightly aromatic taste. It is fairly soluble in cold water, freely in hot, moderately only in alcohol and in glycerin, and but sparingly in ether.

Physiologically, the essential action of kairine is that of a powerful but evanescent antipyretic. Experiments upon animals show reduction of body temperature, along with slowing of rate of pulse and respiration, and, when the drug has been given by hypodermatic injection, anæsthesia and paralysis in the limb receiving the injection. Elimination is by the kidneys, and the urine presents a dark green color, observable, it may be, within half an hour after administration of the drug. Toxic effects have followed when the dosage has risen to between one and two grains per pound weight of the animal. In the human subject, kairine produces certain and speedy lowering of fever temperatures, with less proportionate derangement in the way of roaring in the ears, headache, giddiness, and gastric distress, than the cinchona alkaloids produce. The action, however, is apt to be attended by profuse sweating during the fall of the temperature, and a decided chill when the after-rise begins. Overdosage has produced profound reduction of temperature, with a condition of general collapse, but, so far as the writer knows, no case of death from direct kairine poisoning has been reported.

Therapeutically, kairine has been used as an antipyretic in febrile diseases, and was the first synthetic substitute for the cinchona alkaloids for such purpose. It has, however, been superseded by newer products of the laboratory, such as antipyrin, which are not so severe in operation. A dose of 1 gm. (gr. xv.) of kairine begins to affect a febrile temperature in about an hour, effects its maximum influence within another hour, holds its effect for yet one hour more, and then rapidly fails in potency, so that when a fourth hour has passed since the time of taking the medicine the temperature has commonly reattained its original elevation. By continuous medication, however, a practically continuous depression can be maintained. In ordinary cases, four successive hourly doses of 0.50 gm. each (about gr. viij.) will bring down the temperature to 101° F., at which point it may be held by succeeding doses of half the previous dimensions. When necessary, however, kairine has been given hourly in gram doses (gr. xv.) for four successive hours. Kairine may be administered in capsule, pill, aromatized solution, or elixir. *Edward Curtis.*

KALA-AZAR.—During the last twenty-five years there has been observed in Assam an epidemic fever of a particularly virulent type, which spreads slowly from place to place and depopulates whole villages; it is known as Assam fever, black fever, or Kala-azar. This fever is generally intermittent or remittent, and resembles chronic malaria; its etiology is still undecided, though probably it is of malarial origin. The onset is generally sudden, and the fever is accompanied by wasting, progressive anæmia, and enlargement of the liver and spleen; dropsy is apt to supervene toward the end. There has been considerable discussion as to the cause of Kala-azar; and the Indian government has received no less than three reports on this subject. 1. According to Giles, the chief characteristics are anæmia and dropsy, and the cause is asserted to be the Ankylostomum duodenale, the ova of which Giles found in great quantities in the intestines of those who had died of the disease; the victims had, however, been considerably enfeebled by malaria. He describes it as "a mixed anæmia brought about by ankylostomiasis acting on a population worn down by chronic malarial poisoning" (*Brit. Med. Journ.*, March 26th, 1898).

2. Rogers believes that Kala-azar is essentially a malarial disease, but one which has somehow acquired infectious properties. 3. Ross, whose views have met with the widest acceptance, is inclined to agree with Rogers but thinks that Kala-azar is communicated in the same way as malaria. There can be no doubt that malaria is a most important factor in the production and dissemination of Kala-azar; for all the cases so far reported have been from districts notoriously malarial, and in individuals considerably enfeebled by that disease. It must be remarked, however, that Kala-azar is communicable and epidemic, and is not influenced by quinine. Ross gives three stages of the disease: (1) Stage of parasitic invasion, in which there are recurrent attacks of high fever and rapid enlargement of liver and spleen, particularly the former; (2) stage of secondary effects, in which there are low fever and general tumefaction of the organs; and (3) stage of cachexia, when the fever gradually disappears, the organs decrease in size, attacks of pneumonia and dysentery supervene, the malarial parasite which was formerly present is now no longer found, and there follow cachexia, coma, and death. The disease is particularly fatal, Rogers reporting ninety-six per cent. of deaths; but recoveries do occur. Manson reports cases of two Englishmen who had become invalided in Assam: "both had formerly suffered from malarial fever; in both there was splenic and hepatic enlargement, recurring spells of quotidian fever, unaccompanied by parasites in the blood and uninfluenced by quinine, and attended with profuse diaphoresis, profound anæmia, darkening of the skin, and emaciation. One died of cerebral thrombosis, the other of exhaustion" ("Tropical Diseases," page 221).

Treatment consists in prompt removal from the country to a more healthy locality.

Kala-jwar, or Kala-dukh of the neighboring territory is practically the same as Kala-azar of Assam.

For a discussion on the etiology of Kala-azar, and other facts in reference to the disease, the reader is referred to an article by Ross, in *The Indian Medical Gazette*, vol. xxxiv., pp. 233–241. *R. J. E. Scott.*

KAMALA.—"The glands and hairs from the capsules of *Mallotus philippinensis* (Lam.) Muell. Arg. (fam. *Euphorbiaceæ*)," U. S. P. This plant is a small tree, growing very extensively through southeastern Asia and Polynesia. The fruit is a small tricoccous capsule, covered with a dense, crimson, velvety surface, consisting of the above-mentioned glands and hairs. Kamala is collected by gathering the fruits and shaking or rubbing them about in baskets, and sifting out the dust-like glands. An inferior variety is obtained by taking the glands and hairs from other parts of the plant. The collection of more or less adhering dirt is inevitable, and advantage is often taken of this fact to adulterate it heavily with earthy matters. Hence the fixing of the limit of ash at eight per cent., which is a very liberal allowance.

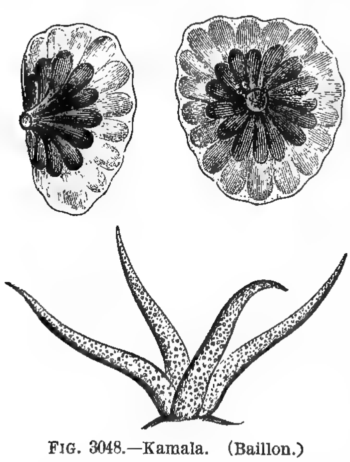


FIG. 3048.—Kamala. (Baillon.)

It has long been used in India, both as a dye and as a medicine, but its employment as a cure for tapeworm appears to date only from the middle of the present century.

The glands consist of an external capsule containing a yellow fluid, and enclosing from forty to sixty club-shaped cells filled with a homogeneous, transparent, red resin, amounting to about four-fifths of the whole weight of the glands.

ACTION AND USE.—The only purpose for which this drug is employed in medicine is as a tænicide, for which purpose it has considerable value; but the discovery of koosso and pelletierine has displaced it from medical favor, and it is now becoming obsolete. From 4 to 10 gm. (ʒ i.—ʒ iiss.) may be given at a dose.

Henry H. Rusby.

KARYOKINESIS. See *Cell.*

KARYOKINESIS. (PATHOLOGICAL.)—Atypical forms of karyokinesis are found in certain pathological conditions. In place of normal bipolar division multipolar division may take place, two, four, six, eight, or more nuclear spindles with a correspondingly increased number of equatorial plates being formed. The number of chromosomes may be greater or less than normal. Asymmetrical splitting of the nuclear chromatin, or the destruction of some of the chromosomes may lead to the formation of daughter stars having an unequal number of chromosomes. In the place of a single mother star a complicated chromatin figure may be formed from which a number of daughter stars may be developed. The separate chromosomes may vary greatly in size, or they may be altered in form through irregularities in the course of the fibres of the spherical, spindle- or biscuit-shaped chromosomes being in this way produced. The division of the cell protoplasm may be delayed or entirely fail of occurrence. Multinuclear giant cells are formed in this manner. Deviations from the normal division axis may also occur. Degeneration of the chromosomes is sometimes shown by their displacement, granular disintegration, or loss of staining power.

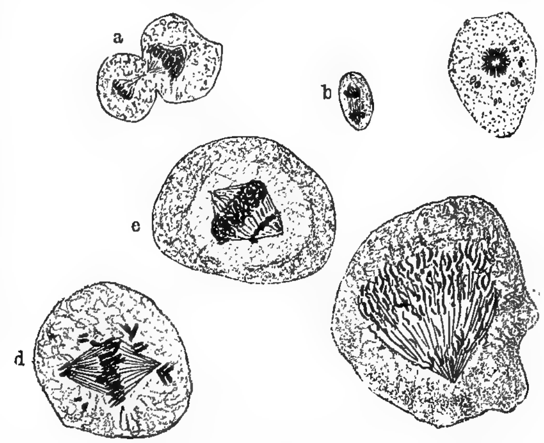


FIG. 3049.—Pathological Mitoses. *a*, Asymmetrical mitosis; *b*, hypochromatic mitosis; *c*, *d*, mitoses with displaced and partly degenerating chromosomes; *e*, *f*, asymmetrical mitoses. (After Hansemann.)

Multipolar mitoses were first described by Eberth, but his statements were at first discredited, particularly by Flemming and Strassburger. The existence of such forms was, however, confirmed later by Arnold who observed numerous multiple mitotic figures in carcinoma cells. As a result of the great amount of interest excited in the subject by Arnold's observations numerous investigations were made, among the most important of which may be mentioned the studies of Hansemann, Ströbe, and Galeotti. According to Ströbe, atypical mitoses are found in a great variety of pathological conditions — cancer, sarcoma, different forms of benign tumors, tissue regenerations, etc. He regards them as a constant phenomenon in all tissues showing strong proliferative tendencies with active mitosis. Galeotti claimed to have found atypical mitoses in tissues irritated by antipyrin, quinine, chloral, peptone, etc., as well as in tissue exposed to high temperature.

Hansemann divides the pathological forms of mitosis into three classes—the hypochromatic, hyperchromatic, and irregular variations. Hypochromatic mitoses are those which contain fewer chromosomes than normal. The number of chromosomes may be reduced to six or eight. Hypochromatic cells arise in two ways, either through asymmetrical division or through the destruction of some of the chromosomes. According to Hansemann, the hypochromatic mitoses occur only in malignant tumors, much more frequently in carcinoma than in sarcoma. They are to be regarded as evidences of cell degeneration; in the majority of cases cell division does not follow. He regards them as being only of biological interest, their significance with relation to tumor malignancy not being at the present understood. The hyperchromatic forms contain more chromosomes than the normal cells. They are very abundant in malignant growths, much more so in carcinoma than in sarcoma. They may be divided into two classes, the bipolar and the multipolar. The bipolar forms are very large, containing over a hundred large chromosomes at times. On division they form similar hyperchromatic cells having the same number of chromosomes. In the multipolar forms a reduction of the number of chromosomes occurs through division, so that their number may ultimately return to the normal. The multipolar mitoses usually result in the formation of multinuclear giant cells, the latter being most numerous in tumors containing the greatest number of multinuclear mitoses. As irregular forms of atypical mitosis Hansemann includes changes in size and form of the chromosomes and centrosomes, irregular spindle forms, delayed division of the cell, etc. Hansemann was unable to confirm the work of Ströbe and Galeotti, and is therefore inclined to regard atypical mitoses as being characteristic of malignant tumors. The presence of numerous atypical mitoses in the cells of a new growth may be taken as positive evidence of its malignancy, but the absence of such pathological forms in a tumor is not to be taken as conclusive proof of its benign character.

A practical application of the above principle has been made by a number of writers in the case of the diagnosis of bits of tissue obtained by the stomach tube, aspirator, etc., or of cells found in pleural and peritoneal exudates, urine, uterine discharges, etc. The existence of carcinoma has been diagnosed by Rieder, Dock, etc., from the presence of numerous atypical mitoses in the cells of the centrifugated peritoneal fluid. Sarcoma of the pleura has been diagnosed in like manner. In other cases, however, the examination of the pleural and peritoneal fluids yielded negative results, though malignant growths were found to be present. Only in the case of very soft, cellular, quickly growing tumors are positive findings likely to occur. In suspected cases the fluid obtained by aspiration should be quickly centrifugated, cover-glass smears made of the sediment; and these, after drying in the air, should be fixed in equal parts of absolute alcohol and ether, and stained in hæmatoxylin and eosin. The presence of numerous mitoses in the cells of such exudates, either typical or atypical, may be regarded as strong evidence of the presence of a malignant tumor. Negative findings are without significance.

Aldred Scott Warthin.

KARYOLYSIS.—The change observed in the nucleus of a necrotic cell whereby its chromatin either entirely disappears or loses its staining power. Such change may be due to a solution of the nucleus, to chemical changes in the chromatin, or to its complete destruction. It is the most important microscopical evidence of necrosis, and is to be regarded as the essential feature of this process. The term is used synonymously with chromatolysis, but is gradually replacing the latter word.

Aldred Scott Warthin.

KARYORRHEXIS.—The term applied by Klebs to that form of nuclear fragmentation in which the chromatin becomes broken up into small particles. It is distinguished from karyolysis in that in the latter process there is a complete disappearance of the chromatin, while in the former the nucleus is broken into particles which are often hyperchromatic. Karyorrhexis is one of the earliest signs of necrosis, and is in the majority of cases a forerunner of karyolysis. The latter may occur, however, without a preceding karyorrhexis, the nucleus losing its staining power without undergoing fragmentation. According to Schmaus and Albrecht, the disintegration of the nucleus in karyorrhexis is not due to a rupture of the nuclear membrane, but is caused by definite and fairly typical movements on the part of the chromatin elements in response to certain influences acting from without the nucleus. The transposition of the chromatin elements is usually preceded by a condition of hyperchromatosis leading ultimately to a separation of the chromatin into single particles which gradually lose their staining power. The phenomena of karyorrhexis may be observed in all forms of beginning necrosis due to any cause, but can be studied to best advantage in the necrosing areas of malignant tumors, particularly in carcinoma.

Aldred Scott Warthin.

KATHELECTROTONUS. See *Electrotonus.*

KAVA.—METHYSTICUM; KAVA-KAVA; AVA. The root of *Methysticum Methysticum* (Forst.) Lyons, and of *M. excelsum* (Forst.) Lyons (fam. *Piperaceæ*). The first-named (generally known as *Piper Methysticum* Forst.) yields the bulk of the drug. It is a good-sized softly woody shrub, native and widely cultivated through the South Pacific Islands. The root has acquired a local reputation as a remedy for dropsy and painful affections of the bladder and the urinary tract, but it is chiefly prized as the source of a native beverage. The plant is reduced to a pulpy mass by mastication and allowed to ferment until an intoxicating liquor is produced. The primary effect is as a stimulant, but ultimately it causes a peculiar form of intoxication in which the limbs and body are uncontrollable and helpless, while the mental faculties are clear or slightly dazed.

Authorities differ as to the resemblance of its effects to those of alcohol. It is not unlikely that by keeping, or by different methods of preparation, alcohol is yielded by the large amount of starch which is contained. Excessive use of it produces a chronic, troublesome scaly disease of the skin.

The root is soft and juicy when fresh, but becomes very light upon drying. It is light-gray in color externally, and pale yellowish-white when cut. It comes in large, thick, clumpy pieces, often 8 or 10 cm. across at the base of the stems, and divides quickly into several crooked, irregular branches. The texture is woody, but soft and light; the sawed surface is dusty or mealy. The odor is slight, the taste rather spicy and bitter, leaving the tongue slightly benumbed for a little while. A transverse section shows a thin bark, and a radiated, woody ring, in which the narrow wood edges are separated by broad, starch-bearing, medullary rays.

Half its weight consists of starch. It contains also an essential oil; two resins, alpha- and beta-resin kava; and a neutral crystalline principle called *kavahin*, or *methysticin*, which is closely allied to *pipirine*. The crystalline body exists to the extent of one per cent., but has been found inactive. The alpha resin, which is obtained by means of alcohol, and is insoluble in water, contains the medicinal properties of the plant, and is thought by Lewin to be the active ingredient. It has, however, been shown that the watery infusion also is useful, and this would indicate that the virtues of the plant are not limited to the resin itself. At present the resin and the fluid extract, not miscible with water, are the preparations employed for medicinal purposes.

Kava-kava has formed the subject of an exhaustive study by Dr. Cerna (*Therapeutic Gazette*, January, 1891) who arrives at the following conclusions regarding its physiological action: Moderate doses produce a stimulating effect, particularly on the central nervous ganglia;

in larger quantities it produces general anæsthesia, and diminishes and ultimately abolishes reflex action by influencing the spinal cord, and probably also the spinal centres. The great muscular weakness observed is not due to any action on the higher cerebral centres, as they maintain their normal functional activity. Very large quantities depress the circulatory and respiratory systems, and, in poisonous doses, death is produced by failure of the respiration or by cardiac paralysis. Placed on the tongue, it at first causes a burning sensation, which is followed by numbness and anæsthesia, which continue for some time and are accompanied by a free flow of saliva. On the cornea and conjunctiva the same effect is produced. The local anæsthetic action is said to be equal to that of cocaine, but its use is restricted by the insolubility of the preparations in water.

Kava is the best simple diuretic that we possess. It quickly produces an abundant flow of pale urine without irritation, but, on the contrary, with soothing effect, and is hence very useful in removing dropsical effusions. At other times its action is favored by the use of an abundance of water. Such use of it is recommended in cystitis, gonorrhœa, and chronic inflammatory conditions of the mucous membrane of the urinary organs. The inflammatory action is rapidly moderated, and the purulent and catarrhal discharges diminish in amount.

The fluid extract is the most convenient preparation to use, and has been employed with decided success. It may be given in doses of ℳ xx.–lx. three times a day, and has been combined with sweet spirits of nitre and glycerin when these are indicated. The alpha resin is given in doses of gr. i.–iss., three times a day. A solid extract is prepared, the dose of which is gr. ij.–vi. The principle, kavahin, is not employed, as its therapeutic action and dose are uncertain. *Henry H. Rusby.*

KEFIR GRAINS.—Kefir Seeds. Small pebble-like or seed-like masses, occurring in the Caucasus region, consisting of a fungus mass containing the ordinary yeast-plant, together with the bacterium *Diospora Caucasica* Kern., and there used for the fermentation of milk into a substance called *kefir*, the equivalent of koumyss. The vitality of the dry grains is excited by soaking in water for some hours before they are introduced into the milk.

Henry H. Rusby.

KELOID.—(Synonyms: Kelis; Kelos; Fr. *Cheloide;* Ger. *Keloid, Knollenkrebs.*)

Definition.—A circumscribed connective-tissue, benign, cutaneous neoplasm resembling an hypertrophic scar and consisting of accumulated embryonic connective-tissue elements.

To Alibert ("Précis théorique et pratique sur les maladies de la peau," 2 vols. 8vo, Paris, 1810, Art. "Cancroïdes," T. i., p. 417. Atlas, pl. 28; Vallerand de Lafosse, *Revue méd.*, October, 1829) belongs the credit of giving the first reliable description of keloid to the medical profession. The term is derived from the Greek word κηλίς, a scar, or χηλή, a claw, and εἶδος, resemblance, from its fancied resemblance to a crab's claw. Alibert differentiated two forms of keloid, the true or spontaneous, kelis genuina seu vera, developing without any injury to the skin, and the false, kelis spuria, also called scar, cicatricial, or secondary keloid, the result of traumatism. This division, however, cannot be adhered to strictly, as the injury is often of such a slight character as to be readily overlooked. The term Addison's keloid refers to morphœa or scleroderma circumscriptum, and is to be distinguished from the affection under consideration.

Symptoms.—Keloid usually begins as an elevated nodule or tubercle, or several nodules may coalesce, varying in size from a pea or a bean to that of the hand. Its favorite seat is on the trunk, particularly over the sternum, although it may occur on the mammæ, neck, ears, and arms. The tumor consists of a hard, fibrous growth, is irregular in contour, the surface is smooth or covered with lanugo hairs, the epidermic covering is thin and of a white or pinkish color, due to the presence of dilated capillaries; it is firm and elastic to the touch, adherent to the cutis, and elevated and sharply defined. Keloid presents not only variations in size but also in form, at times appearing as a tumor of oval shape, from which prolongations extend into the surrounding neighborhood, resembling the appearance of crab's claws, at times it is simply ovoid or nodular without projection. Again it is met with as an elongated, cylindrical growth, or occurs as elevations, resembling cords or in the form of bands or ridges. Occasionally a slight depression of the centre with elevated margin exists. Keloid slowly increases and may remain stationary for years, and usually it persists throughout life. Even when the tumor has existed for years, ulceration never takes place, and spontaneous involution has been observed to occur in very exceptional cases. Although usually single, keloids may be quite numerous, and at times are distributed along the course of cutaneous nerves. Schwimmer in one case reported one hundred and five, and De Amicis in another individual three hundred keloids. Usually the growth is painful, especially when it is subjected to pressure, and occasionally the pain may be spontaneous. In some cases pain is entirely lacking. At times a pricking or burning sensation and occasionally itching are experienced; when the growth is situated on the flexor surfaces of articulations, it may interfere to some extent with motion.

Etiology.—The etiology of so-called spontaneous keloid is obscure, and it is regarded as of exceedingly rare occurrence; it is highly probable, as already stated, that it is due to injury of the cutis so minute in character as

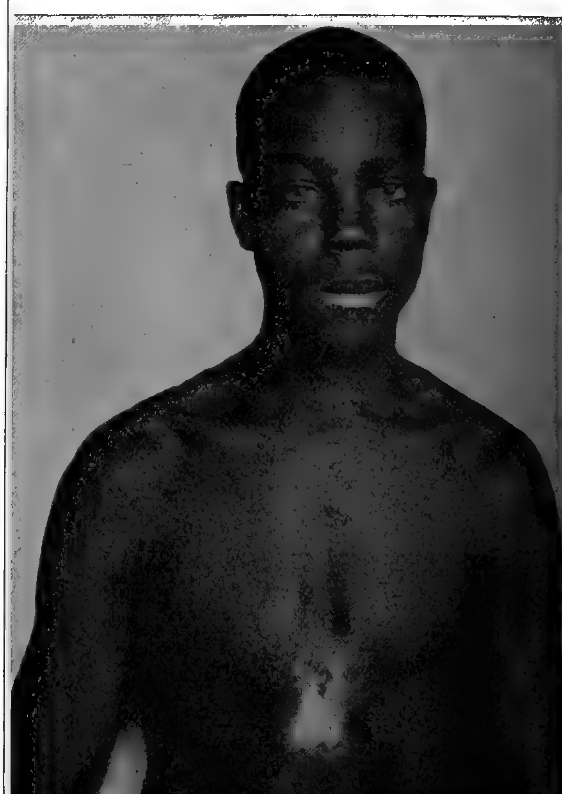


Fig. 3050.—Keloid of Sternum Developed after a Burn.

to be readily overlooked. Sex does not appear to influence its occurrence, although some observers are inclined to regard it as being of greater frequency in females than in males. It has been observed at all ages, although it is of rare occurrence in the very young and very old, and

usually appears during middle life. It is met with most frequently in tropical countries, and it appears that certain families and the negro race are predisposed to keloid. Cicatricial or scar keloid, on the other hand, is often met

Fig. 3051.—Keloid of Inferior Maxillary Bone following an Operation. Figs. 3050 and 3051 illustrate the occurrence of keloid in two negro brothers.

with and may appear in any locality. As an example of the disease occurring in the negro race and as an argument in favor of family predisposition (see Hebra's case in which three sisters and the mother were affected, "Hebra," vol. iii., p. 278; Wilson and Bryant have also recorded instances), the author would briefly quote the following cases: In the one individual, eighteen years of age, there existed a tumor on the sternum, about midway between the manubrium and ensiform cartilage. It dated from the third year of life and developed as a result of a burn. The tumor was about three inches in width by five inches in length, was elevated about one-sixteenth to a quarter of an inch over the surrounding skin, was sharply defined and felt firm and elastic to the touch. It was irregular in contour, and characteristic claw-like processes extended on either side, both laterally and above and below. The surface of the growth was smooth and totally devoid of hair, and the color was whiter than that of the neighboring parts; dilated blood-vessels on the surface were not visible. In the second case, a brother of the foregoing individual, aged twenty years, there developed in the scar, two weeks after removal of a tumor (presumably sebaceous), a keloid. This was situated on the ramus of the inferior maxillary bone, and extended from a point just below the articulation to one situated a little in front of the angle of the jaw. The growth projected about one-quarter of an inch above the surrounding surface, was of rather oval shape and of a lighter color than the adjoining skin, and measured about three inches in length by about two in width. On either side of the growth there existed three small keloids marking the site of the introduction of the sutures for closing the wound after operation.

Scar keloid often follows burns, operations, and other slight cutaneous injuries. Thus it has been observed to occur after blisters, in the lobe of the ear after piercing for earrings, in the scars of leech bites, also after the scars of eruptions of smallpox, acne indurata, syphilis, herpes zoster, and non-parasitic sycosis, and in vaccination scars. The writer recently had occasion to observe, on the right cheek of a young lady, a keloid that had developed after an attack of dermatitis venenata. It has also been known to follow after psoriasis and is not infrequently seen (in male individuals of the African race) in the form of small, indurated, whitish, elevated lesions due to shaving.

Pathology and Pathological Anatomy.—Keloid is a growth consisting of dense, fibrous connective tissue, situated in the corium. According to Warren, the disease originates in the vessel walls of the corium, which are involved to quite a distance beyond the growth, which would explain the recurrence of the neoplasm after extirpation. The same observer states that it is impossible to differentiate between true and false keloid with the aid of the microscope. According to Kaposi, in true keloid the sections present a whitish, dense fibrous mass, the fibres running parallel to the long axis of the tumor and the surface of the skin; here and there they run in a vertical direction. The new growth is inserted in the corium in such a manner that normal layers of the latter, particularly the papillæ and rete pegs, remain intact, while they are wholly absent in the hypertrophic scar. There are a few nuclei and nucleated spindle cells within the keloid body and around the vessels, which are compressed, as if by a sheath, by the dense bundles of fibres. The cells are abundant in the younger parts of the keloid, around the arteries; indeed, it appears as if the fibres of the keloid were derived from spindle-shaped cells sheathing the vessels. Neumann states that in keloid a new growth of parallel connective-tissue fibres takes place, and that these fibres are situated, in the shape of a wedge, in the substance of the corium and ultimately displace it entirely. Spindle-shaped cells accumulate along the adventitia of the vessels, especially of the arteries; a few oblique bundles may occur here and there. The sebaceous and sudariparous glands at first remain unchanged, later they disappear and the glandular substance in the centre of the keloid is lost. The tumor

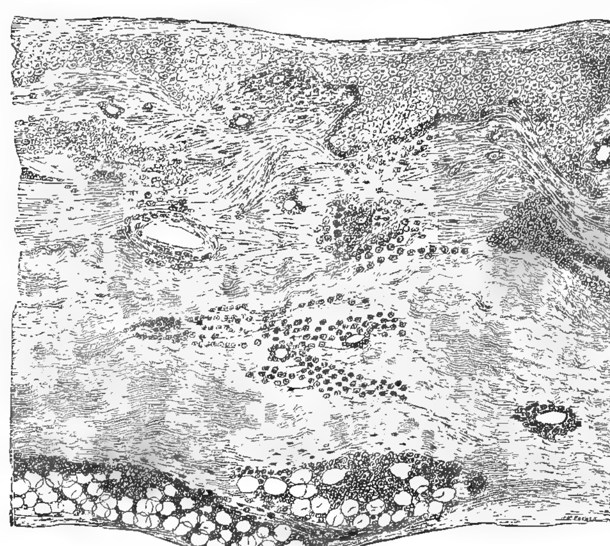


Fig. 3052.—Cicatricial Keloid from the Gluteal Region, following a Burn. *a*, Epidermis; *b*, Malpighian layer; *c*, remains of papillary layer near the border of the tumor; *d*, keloid tissue. The cellular infiltration around the blood-vessels is also indicated at several points. (From an original drawing by Dr. James M. French.)

develops in the following manner: Spindle-shaped cells appear along the vessels, especially the arteries, and they extend even into the neighboring normal tissue. This change in the adventitia is especially noticeable along the

margin of the new growth and at those points where the arteries give off branches to the papillæ. The disease extends along the vessels of the corium.

Diagnosis.—This is not usually difficult, as the symptoms are so characteristic as to render an error almost impossible. From a simple cicatrix keloid is to be distinguished by its course, color, contour, consistence, elevation, and frequently by the presence of pain. The diagnosis between spontaneous and spurious or cicatricial keloid is of no special importance. Hypertrophic scar differs from it in not extending beyond the limits of the injury, and in the facts that claw-like prolongations are absent, and that the tissue of the new growth is less pinkish in color and less permanent. Morphœa or scleroderma circumscriptum, occurring in raised patches, may simulate keloid to some extent; the latter, however, differs from the former by being more vascular, denser, and more elevated and by having claw-like prolongations.

Prognosis.—The prognosis is unfavorable. Spontaneous involution is of rare occurrence. According to some observers, a keloid which has developed on a syphilitic scar is more apt to undergo involution. The growth does not interfere with the general health and may, after having attained a certain size, cease to enlarge and remain stationary.

Treatment.—The treatment of keloid is unsatisfactory; plastic surgery has accomplished very little in this affection. When removed with the knife or with caustics the growth is almost certain to return, and usually in a more aggravated form than before operation. According to Duhring caustic potash offers the most efficient remedy if an operation is insisted upon; he advises, however, against its employment if the disease is increasing. Erasmus Wilson paints the growth with a spirituous solution of soap and potassium iodide, and then keeps it constantly covered with lead plaster, spread on wash leather. Pressure with flexible collodion resulted in a cure in Professor Da Costa's hands in a case ensuing after variola. Pressure carefully applied with an elastic bandage has proved successful in Verneuil's hands; it should be distributed in such a manner as to avoid friction which might have a tendency to favor the growth of the tumor. Hardaway reports good results in one case from electrolysis; it is not safe, however, to employ a strong current for fear of stimulating the growth. Multiple scarifications, frequently repeated, have been followed, according to Vidal, by complete cessation of pain and diminution in the size of the growth. Severe pain may be combated with hypodermatic injections of morphine or cocaine. Chloroform liniment and applications containing belladonna or stramonium or emplastrum hydrargyri may also be resorted to for this purpose. Internally quinine, potassium iodide, and arsenic have been employed, but they are all of questionable utility. Local applications of remedies which promote absorption, such as tincture of iodine, iodized glycerin, etc., have all been found to be ineffectual. Recently Dr. Marie (*La Sem. médicale*, 1893, No. 14) has advocated injections into the keloid of a twenty-per-cent. sterilized solution of creosote in oil with a Pravaz syringe; this operation, as he states, being soon followed by slight swelling and paleness of the tumor, and also by pain which may last for several hours. After a lapse of two to three days the tumor assumes a violet-blue color, a vesicle forms on its surface, and then later the whole growth undergoes a transformation into a dry cicatrix. It is stated that by this process the tumor is embalmed and the skin in the neighborhood of the keloid does not become inflamed. *Emmanuel J. Stout.*

KERATIN.—The important constituent of the corneous layer of the skin and its appendages, extracted for use as a resistant coating against the gastric secretion. It is chiefly obtained from quills, or from horn. Various methods of preparation are employed, their object being to eliminate such substances as can be attacked by the gastric juice. One of these methods consists in eliminating such substances by maceration in a solution of hydrochloric acid and pepsin and extracting the residue. Besides being insoluble in the gastric juice, it is so in alcohol and water, but is soluble in strong acetic acid, also in alkalies, hence in the duodenal contents. Keratin is used to coat pills containing substances, the action of which upon the stomach or upon its contents is undesirable or objectionable, but which is serviceable in the intestine. It apparently has no action of its own, except slightly as an albuminoid nutrient. *Henry H. Rusby.*

KERATODERMA PALMARE ET PLANTARE.—(Synonyms: *Keratoma palmare et plantare, hereditarium, ichthyosis palmaris et plantaris, tylosis palmæ et plantæ.*

Definition.—Keratoderma of the palms of the hands and of the soles of the feet is an affection characterized by a thickening of the horny layer, of a leathery consistence, yellow or brown in color and more or less symmetrical.

From a purely clinical point of view, much vagueness is attached to the term keratoderma, as it includes thickening of the palmar and plantar epidermis, the result of several and distinct causes—lupus for example, which is associated with a diminution in the epidermal tissue, except at the extremities, where it associates itself with hyperkeratosis. Dry eczema may show at all points an increased production of horny tissue, from which an extensive desquamation results, while at the palms and the soles the horny substance accumulates in such a manner as to cause the condition known as keratoderma. On the other hand, in default of the histological characteristics, we take the word hyperkeratosis, in a strictly clinical sense, to mean hypertrophy of the horny layer. Nevertheless, it is generally maintained that the palms and the soles are regions specialized by their structure; that no analogy exists between them and the other parts of the body by reason of their situation, their necessary exposure, and the exterior influence to which they are continually subject, showing that the hands and the feet should be affected in the same manner by the same disease. There can be no doubt that in the future, no matter what classification is adopted, the diagnosis will be founded upon characteristics revealed by the microscope. For upon microscopical examination depends the differentiation of the great variety of palmar and plantar hyperkeratoses. As they are the outcome of very different conditions and diseases, some being generalized, or diffused, while others are localized, a comprehensive and satisfactory classification becomes extremely difficult.

Symptoms.—The Besnier classification embraces four principal divisions:

I. The symmetrical keratodermata of the extremities, congenital and hereditary, with or without nævi on any portion of the body. As a rule, the disease has been observed during the first weeks of life, yet its development has often been delayed until the close of the year, or even as late as the third or fourth year. It begins as a diffuse redness of the palms and soles, and later becomes scaly; after which the redness disappears, when the condition establishes itself and the epidermal thickening commences. At certain points it may become circumscribed and resemble calluses (Plate XXXVII., Fig. 2). In the folds of the flexures there are often deep rhagades. In extreme cases the horny layer is ploughed into fissures of a greater or less depth. The abnormal epidermal thickening of the involved areas generally stops abruptly, conforming to the outline of the palms, but quite often it extends to the back of the fingers. The horny carapace sometimes preserves its natural color—an amber yellow—or may become gray or black by the penetration of dust. Its surface is wrinkled, and it desquamates in the form of irregular masses.

This special type is not always well defined—in some cases it builds limited plaques. It may sometimes affect other parts of the body, such as the knees and elbows. Once established, the disease continues indefinitely and is likely to be worse in winter.

II. The common symmetrical keratodermata which develop in adults, possibly related to some central neurosis, are erythematous and influenced both by weather and by

EXPLANATION OF
PLATE XXXVII.

EXPLANATION OF PLATE XXXVII.

Fig. 1.—Hyperkeratosis of the Sole of the Foot, following Eczema. Model No. 2062 (M. Baretta), Balzer.

Fig. 2.—Congenital Keratoderma of the Palm of the Hand. Model No. 1832 (M. Baretta), Dupré and Mosny.

(From *La Pratique Dermatologique*, 1901.)

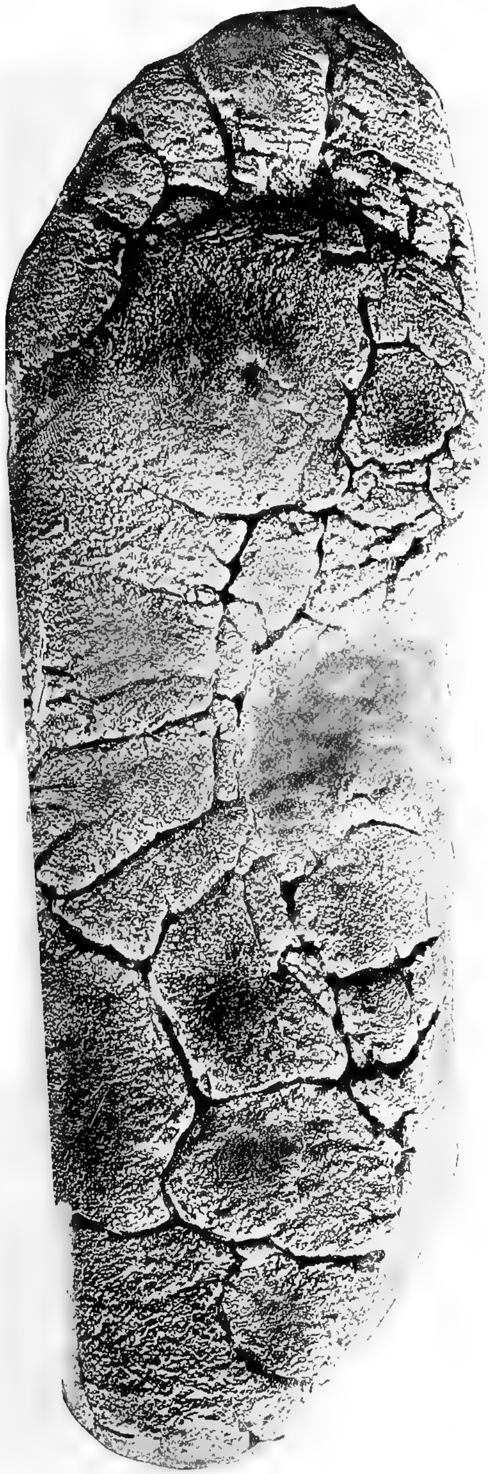


FIG. 1.

FIG. 2.

KERATODERMA PALMARE ET PLANTARE

manual toil. These lesions of hyperkeratosis are disposed superficially at the palmar surface of all the fingers, and at the anterior and inferior extremities of the metacarpus, especially near the summit of the thenar eminences. The keratinized patch is usually surrounded by an erythematous border, and upon removal of the horny layer even the elongated papillæ give evidence of hypertrophy. There is no pain except when caused by fissure; the condition is usually associated with hyperidrosis. The nails are often affected. On the feet the keratosis is better defined than on the hands.

III. The keratodermata of the extremities, which develop like foci in isolated and multiple islets on the palms of the hands and the soles of the feet, are out of all proportion to the degree of pressure which may have been brought to bear upon these parts, and it is therefore permissible to believe that the disease has a trophoneurotic or central origin. There are several varieties, of which the most remarkable one has the orifices of the sudoriparous glands for foci; these are distended by horny plugs resembling comedones and possessing concentric lamellations. Belonging to this class are the symptomatic keratodermata, when limited to the palms and soles, and also when associated with some general dermatosis. In this group it is also proper to consider the type produced by arsenic and the types due to palmar and plantar localization of eczema, psoriasis, lichen planus, pityriasis rubra, and syphilis. Hyperkeratosis is one of the principal effects of a prolonged ingestion of arsenic, most marked in the palms of the hands and the soles of the feet, though it may involve the skin elsewhere. The thickening is not necessarily confined to the palmar or the plantar surface, but may extend to the adjacent parts. In the mild variety, which is not very rare, the palms and soles become slightly dry, and the epidermal markings coarse and exaggerated, mixed here and there with small, white, horny granules about the size of a pinhead, which can readily be removed. In the more pronounced forms, which appear only after arsenic has been taken for a long time, the horny layer assumes a uniform thickness, compact in structure, amber in color, very supple to the touch and without rhagades. At other times, however, it becomes grained or shagreen-like, with hyperidrosis, in which case the palms are soft and humid. Should the sweat be but normal the skin will be found usually dry. Palmar and plantar keratoderma occurs most frequently in association with eczema. It may not only attack the hands, but (more rarely) the feet alone; it often attacks all the extremities. It may be symmetrical, but usually one side is affected more than the other. Itching is a constant symptom, although at times it may be but slight. Palmar and plantar keratonized eczema is a disease specially belonging to old age. The keratonized eczema of the soles presents about the same characteristics as that observed in the palms, although the hypertrophy of the horny layer is more marked (Plate XXXVII., Fig. 1). It forms a hard, gray, more or less black shell around the heel, displaying a mass of quadrangular crevasses characterized by long and deep rhagades which run in various directions, and cause the patient considerable discomfort. While hyperkeratosis has frequently been noted as a complication of eczema, it is nevertheless unusual in the majority of cases. Palmar and plantar psoriasis begins with distinct papules which continue to develop at the periphery, the edges alone showing hyperkeratosis, in the form of a very distinct border surrounding the desquamating area. Lichen planus of the palms and soles is rare and is not always hyperkeratotic. It is found alike in the generalized and in the acute forms, in which the palms and soles are covered with papules having a hypertrophied epidermis. Later, in more chronic cases, these surfaces are covered with a thick, horny, yellow, and translucent layer. Syphilis may give rise to the development of keratoderma, and the latter differs with the various stages of the disease. During the secondary stages it shows itself especially on the palms of the hands. The older the lesion the thicker the epidermis, which slowly desquamates. In the tertiary stages palmar syphilides are more frequent and extensive; the areas often become infiltrated and covered with a thick, horny epidermis, frequently raised like collarettes and cut by deep rhagades.

IV. The keratoderma of the extremities, which appears at all ages under the influence of unaccustomed pressure, is not to be confounded with ordinary callosities. This variety readily responds to treatment and is usually curable.

Etiology.—Heredity is a dominant trait in the etiology of this disease, and, as in ichthyosis, tends to affect only one sex in the same family. From an etiological standpoint we should perhaps separate from this group acquired types appearing in adults. The most ordinary factor in the production of keratoderma is the remedial use of arsenic, although arsenical intoxication has resulted from drinking water which contained the drug, and, recently in England, from the use of beer containing it. Local irritations sometimes play a very important part; certain cases have resulted from contact with acids or alkalies, or from traumatism, such as the habitual use of tools. Another interesting class constantly met with is that induced by inflammatory changes of certain diseases, such as eczema, psoriasis, syphilis, and lichen planus.

Pathology.—The pathology, while meagre, corresponds in general with that of callosities. Besnier and Balzar have noted that the horny layer for a great part of its depth is infiltrated with eleidin; that there is an increased thickness of all the layers of the epidermis; that the papillæ are sometimes elongated and thinned and at other times thickened and shortened by reason of the multiplication of the cells which compose them. Beneath this layer of shortened papillæ there is found, in many cases, a hyperæmia of the upper layer of the derma.

The histological findings reported by Brooks and Roberts in an article relating to the action of arsenic on the skin, as observed in the recent epidemic of beer poisoning, are here largely reproduced. An examination of sections of the lesions affected by acute erythematous hyperkeratosis showed that the pathological changes presented a hypertrophy of the epidermis, especially of the stratum mucosum. The cells were large, with well-proportioned nuclei; they had clearly defined walls, and revealed very distinct prickles. There was no œdema or mitosis. An accumulation of horny cells appeared in the upper layers of the epidermis. If the skin had been subjected to the influence of arsenic, the vertical cells drooped and leaned to one side, and the nuclei changed their shape and were filled with pigment granules. Later, the process of degeneration set in, ending in atrophy. The rete almost entirely disappeared and at times only one or two rows of cells remained behind; the stratum granulosum and stratum lucidum showed marked evidence of degeneration, finally ending in atrophy of the sweat and sebaceous glands. The epithelium was reduced to a very thin layer, with the entire disappearance of the stratum lucidum, and showed horny plates. In the later chronic stages the whole of the epidermis was filled in with pigment, producing a black discoloration. The excretory portion of the sweat glands was stained black by osmic acid, leading to the conclusion that the amount of fat had been increased.

Diagnosis.—Keratosis palmaris et plantaris is to be differentiated from that produced by eczema by the absence of the well-defined inflammatory symptoms of that disease, by its appearance on other portions of the body, by the lack of variability in its symptoms, and by the limitations of the plaques. Palmar and plantar psoriasis is distinguished from the other forms of keratosis, at the beginning, by its distinct papules and, later, by the marginate disposition of the plaques—the border also showing the keratosis. Palmar and plantar syphilides are always to be considered with caution, and are especially to be distinguished from psoriasis of the same regions. The differences lie in the multiplicity of the lesions, their redness, the more marked infiltration of the border, and the presence of bulky and horny scales. The external appearances of arsenical keratoderma are very characteris-

tic; almost invariably there will be found a symmetrical hyperkeratosis of the hands and feet, with a horny layer which has an almost uniform thickness and is supple and without fissures.

Prognosis.—Congenital keratoderma is an ailment of a most uncomfortable nature on account of its incurability. Sometimes it is so severe as to interfere with all manual labor which requires delicacy of touch. All the types of this disease that constitute a secondary manifestation are curable, although, in the most favorable circumstances, they are exceedingly obstinate to treatment, and require long periods for their permanent correction.

Treatment.—For the hereditary type of keratoderma, arsenic in large doses has been recommended, particularly the arsenite of sodium as suggested by Brocq. There are, however, many misgivings among physicians as to its virtue. The only practical treatment is local—the attempt should first be made to cure the rhagades by proper applications and by the removal of the horny masses. Afterward such measures should be adopted as will tend to arrest the persistent tendency, on the part of the epidermis, to reproduce layer after layer of a horny character. Hyperkeratosis due to arsenic is of course cured by discontinuing the use of the drug. When it is due to eczema the treatment consists in suppressing the local or general influence which has produced that disease. When it is the result of occupation or of contact with irritating substances, the occupation must be abandoned and the substances avoided. In fact, the internal treatment indicated for lichen planus and for pityriasis rubra pilaris should be carried out when keratoderma is associated with either of these affections. The local treatment in all types is about the same—prolonged maceration of the parts, followed by shampooing with green soap, supplemented by strong plasters of salicylic acid or resorcin. Mercurial plasters may also be used to advantage. A very good treatment is recommended by Unna; it consists in dressing the affected part with compresses immersed in a two-per-cent. solution of resorcin, and then enveloping these with rubber tissue. These dressings are to be worn at night, removed in the morning, and followed by an application of salicylic-acid ointment. *Grover W. Wende.*

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KERATOHYALIN. See *Cornification.*

KERATOSIS FOLLICULARIS.—(Synonyms: Psorospermosis, *Psorospermose Folliculaire Végétante,* Ichthyosis Follicularis, *Acne sébacée cornée,* Darier's Disease).

Definition.—Keratosis follicularis is a hypertrophic affection of the general integument, characterized by pinhead- to pea-sized horny plugs, embedded in funnel-shaped dilatations of the pilo-sebaceous follicles. This rare affection of the skin was almost simultaneously described by White, Bowen, and Darier. It had, however, previously been recognized under other names, although positive histological proof was lacking. The interesting observations of Darier relative to the striking cell forms that resemble coccidia and that are found in the skin lesions, and his first conjecture that these cells are parasites, resulted in very careful examinations on the part of many investigators, as well as the reporting of numerous cases. It has turned out, however, that White and Bowen were correct as to the nature of this disease and that Darier's protozoan interpretation was wrong.

Symptoms.—The primary efflorescences appear in the form of pinhead-sized papules, more or less raised and covered with greasy scales that vary in color from a dirty yellow to a black brown. These scales cling together with considerable tenacity, and, when removed, frequently show on their lower surface a dingy, conical projection which may, although with some difficulty, be rubbed away, and which sometimes corresponds with the orifices of the sebaceous follicles and always with the funnel-shaped depressions of the upper skin which are independent of the follicles. The periphery of these primary lesions becomes expanded by the deposit of new, dirty-gray to black-brown foci the size of a lentil, which run together into large, irregular plaques, bordered at their edges by disseminated primary efflorescences, whose surfaces soon appear more or less glandular and warty. These efflorescences soon become flatter and rise above the level of the skin in the same manner; the plaques growing out of them may also attain considerable size. In one case reported by Darier, these hill-shaped efflorescences, devoid of epidermis, ran together on the pubes into large tumors, which were separated by deep furrows. They were bright red in color and showed numerous crater-like orifices containing secreted pus which emitted a decided odor. Besides these peculiar changes there were present, in almost all the recorded cases relating to the scalp, fatty yellow to brown, and often slightly warty, masses of scales penetrated by hair. Sometimes these were reddened, moist, and excoriated, at other times they were not essentially changed. The dorsal surfaces of the hands, feet, and fingers appeared at times to participate in the disease process. The nails were almost habitually involved whether there were like changes in the fingers or not, being generally striated longitudinally and rent or fragmented at their free edges. In some instances the palms and the soles showed a considerable callous formation. In the course of the affection there were manifestations exhibiting distinct exacerbations and remissions. This condition at times almost disappeared, but no instance of actual recovery has yet been reported.

Etiology.—Its inception, in regard to the time of life, is very variable; generally it appears late in childhood, or early in youth, but in some cases it is deferred to a period between the ages of twenty and thirty-five years. In a case of Hallopeau's, the disease first appeared in the sixty-first year. It has been known to manifest itself in both father and daughter, which fact would suggest heredity.

The bacteriological examinations have been constantly negative. The theory advanced by Darier, and later elaborated by Wickham, that this variety of keratosis was due to the presence of psorosperms, or coccidia, has been abandoned even by those authorities themselves; consequently, the precise nature of the disease still remains wholly in the dark.

Pathological Anatomy.—Upon this point all authorities have reported similar results. The changes chiefly occur within, or in close proximity to, the mouths of the pilo-sebaceous excretory ducts. These are dilated so as to form funnel-shaped openings, which are filled with a mass of horny cells continuous with the scales that cover the follicular opening. The wall of the follicle is composed of thick, horny layers limited to the rete cells. The epidermis generally appears more or less thickened. The rete Malpighii appears as if hypertrophied; the interpapillary prolongations are lengthened and press firmly against the corium. The epidermis and the horny masses constituting the summit seem partly to consist of horny lamellæ of normal appearance, but piled up one

upon another in great strands, partly composed of abnormally horny cells in which the nuclei are well preserved. A defective formation in the lower layers of the rete Malpighii, in association with degenerated cells, lymphoid cells and fibrin, and connected with the degenerated processes of the rete cells, is described as typical of the affection. There also appear in the epidermis numerous peculiar elements which Darier has designated as psorosperma. These round bodies, according to the same authority, are represented by corpuscles which show a more or less clearly defined cell and a granulated protoplasm, and are surrounded by a refractive membrane. Almost all authorities at the present time believe that the psorosperma of Darier are only degenerative forms of the rete cells, a conclusion which he himself has recently adopted, and are not an exclusive phenomenon of keratosis follicularis, but also occur in lichen ruber and lupus erythematosus circumulæ. Darier, however, firmly contends that their abundance constitutes a characteristic element of the disease. Besides these changes, there is an increased amount of pigment in the contents of the basal cell layer at the periphery of the efflorescence, while the horny layer contains but little or no coloring matter. This layer, however, shows more or less granular pigment. In the region of the elongated papillæ of the corium there is generally found a moderate infiltration, which has been described as consisting of plasma, connective-tissue or mast cells, and leucocytes.

Diagnosis.—The diagnosis of a well-developed case presents few or no difficulties. One of the diseases it early resembles is lichen planus, although the horny plugs occupy the mouth of the dilated follicles. Large verrucous lesions in the inguinal regions are characteristic. It differs from molluscum epitheliale in not being so generalized, and invariably exhibits an enucleable mass containing the so-called molluscum bodies. The disease bears close resemblance to some types of ichthyosis, but careful study enables us to differentiate it. The lesions in the one undergo a definite and characteristic development not observed in the other.

Prognosis.—The prognosis is unfavorable in nearly all the cases heretofore reported. The disease has lasted for years without undergoing spontaneous involution. The general health of the patient is unaffected, other than in the way of subjective sensations. Treatment has very little influence upon the disease.

Treatment.—The therapeutics of keratosis follicularis have hitherto been of little benefit. A heightened irritability of the skin limits the use of the common remedies employed in hyperkeratosis, such as salicylic acid, resorcin, pyrogallic acid, and chrysarobin. Sulphur, especially that form known as Vleminckx's solution, is applied to the affected places, after which they are to be scrubbed with soap and water, carefully dried, and then covered with some soothing application. In general, the remedies for eczema seborrhoicum should be tried, as there are striking analogies between the two diseases.

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KERATOSIS FOLLICULARIS CONTAGIOSA.—This type is the same as that which was formerly characterized by the name of acne sebacea cornea, an appellation originally bestowed upon it by Dr. Prince A. Morrow, the term contagiosa having been added by Dr. H. G. Brooks, who was the first to observe this particular association.

The type begins with small, black points, usually seated on the elbows and knees, afterward extending up the arms and thighs and finally invading the greater part of the surface of the body. The face may also be affected, while the scalp remains free; the distribution is symmetrical. The black points soon become prominent. Coupled with these are large, sharp-pointed comedones around which papules are finally developed, some of which become inflamed. The lesions mostly, although not exclusively, occupy the pilo-sebaceous follicles, and consist essentially of a hyperplastic proliferation of the epithelial cells, combined with modification of the process of keratinization which allows them to preserve their vitality during a longer period than that pertaining to inflammatory exudations. The lower layers of the stratum granulosum are primarily attacked, not only at the level of the sebaceous follicles, but also in the excretory duct of the sudoriparous glands, and in the interpapillary prolongations of the epidermis. No micro-organisms were found in the cases quoted by Brooks. The contagious nature of the disease was simply conjectured on account of its distribution and for the reason that it affected the entire family at the same moment.

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KERATOSIS PILARIS.—(Synonyms: Lichen pilaris, pityriasis pilaris, ichthyosis follicularis, *xerodermie pilaire, ichthyosis anérine des scrofuleux*, cacotrophia folliculorum.)

Definition.—Keratosis pilaris is a hypertrophic affection, chiefly of young persons, characterized by the formation of small, horny elevations developed around the orifices of the hair, under the influence of a process tending to atrophy.

This form of hyperkeratosis, as now accepted, was originally described as a separate disease, first by Hyde, then by Brocq. It had previously been regarded as one of the manifestations of ichthyosis, with which it often coincides, but from which it differs in localization, histopathology, and evolution.

Symptoms.—In its most common form, keratosis pilaris is characterized by pointed pinhead-sized elevations, developed around hairs, and consisting of an accumulation of horny epithelia around the lanugo hairs on the extensor surfaces of the extremities and trunk. In a more advanced stage, rounded papules appear with an acuminate summit, usually normal in color, hard to the touch and varying in size from a millet seed to a grain of hemp. Sometimes, however, the aspect of the part affected is more or less red, the condition being accompanied by congestion. The hair assailed is more or less atrophied, is seen to pierce each papule, and may be twisted; its calibre is often unequal and, when removed with the finger nail, its locality is marked by a depression. Brocq points out, at the side of these papules, incomplete elements, aborted, in the way of retrograde evolution. These are single spots, perifollicular, erythematous, or, in the last cases, representing cicatrices. The affection is sometimes pruriginous.

The middle portion of the back of the arms, as well as the forearm, the buttock, and the front of the leg above the knees, may be involved. The flexor surfaces, and the middle of the trunk alone remain free. On the face, the eruption presents peculiar characteristics; the prominences are very small and confluent, their presence asserting congestion. According to Brocq, the favorite seats of this dermatosis are the face and the forehead, where it forms two red plaques above the internal third of the eyebrow, occupies either the internal or external front of the ear, or is disposed in a vertical plaque reaching from the temple to the angle of the jaw. The space between the eyebrows, or the middle of the chin, in very pronounced cases, may be involved. The scalp presents desquamation like that of seborrhœa. Brocq has observed, in connection with keratosis, the formation of circumpolar papules and cicatricial atrophy, both of which he connects with moniliform aplasia of the hairs of the head and body. This condition corresponds to the ulerythema

ophryogenes of Taenzer and Unna and the xeroderma of Besnier.

ETIOLOGY.—This disease is shared in greater or less degree by a majority of people. It is usually attributed to lack of bathing, but may occur in persons who scrupulously observe hygienic rules. It may appear before puberty, although, as a rule, it does not. It is wanting where the hairs are atrophied, and it becomes attenuated and finally disappears with advancing age, the pilar system having become more atrophied. The disease is seen most frequently in persons having a thick, coarse, dark-colored skin.

PATHOLOGY.—Keratosis pilaris is essentially characterized by a hypergenesis of the epidermic cells in the hair follicle. The cells of the Malpighian layer in the hair follicle are found to undergo rapid cornification and to be arranged loosely around the hair shaft, so as to form a plug which projects above the surface. The hair shafts may be included. These are often twisted and deformed and the papillæ of the root are reduced in size, or entirely wanting. Patches of necrosis are found here and there at the point of insertion of the arrectores pilorum. On the other hand, actual infiltration may occur, usually affecting the superficial rather than the deeper portions of the follicles. Giovanni found in many cases that the sebaceous glands were entirely wanting, while, in the rest, they were reduced in size. As a rule, the sweat glands were unaffected.

DIAGNOSIS.—Keratosis pilaris differs from goose-flesh (cutis anserina) in its permanency and in the fact that it is uninfluenced by temperature. Pityriasis pilaris rubra is the only dermatosis which is able to simulate the affection. There is this difference, however: the latter is characterized by peripolar and squamous prominences, exhibiting a peculiarly dark and smirched appearance, on the back of the fingers; by the affection of the nails; and, finally, by palmar and plantar desquamation. Keratosis pilaris is distinguished from the papular syphilides by its persistently unchanging character and the absence of specific concomitants.

PROGNOSIS.—The general health is in no wise affected by the disease, even when most pronounced. The disease is curable, but, without proper treatment, may last indefinitely.

TREATMENT.—Frequent baths with the use of a proper toilet soap, or, better still, sapo viridis, will usually be found curative. Alkaline, Turkish, and vapor baths will also be useful, although, in very obstinate cases, Brocq considers that the surest treatment is the destruction of the hair follicles by electrolysis. *Grover W. Wende.*

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KERION. See *Trichophytosis.*

KEYSTONE MINERAL SPRING. — Androscoggin County, Maine.

POST-OFFICE.—East Portland.

LOCATION.—This spring is located in the town of Poland, about one mile from the Empire Road Station, on the Grand Trunk Railway, and about two miles from the Portland and Rumford Falls Railway. It is thirty miles from Portland and six miles from each of the two cities of Lewiston and Auburn. The spring is situated on an elevated ridge of land, and the water itself issues from a bed of rock barely distinguishable from granite, which can be seen in and about the spring. The water flows through a glass pipe direct from the spring into bottles, jugs, etc., which are being filled, and is not taken from storage tanks. According to Prof. Richard C. Stanley, of Bates College, the water contains about three grains of solid matter to the United States gallon, composed as follows:

ONE UNITED STATES GALLON CONTAINS:

Solids.	Grains.
Iron carbonate	0.45
Iron oxide	.25
Magnesium carbonate	.65
Potassium and sodium carbonate	.30
Potassium and sodium sulphate	.25
Sodium chloride	.25
Silica and alumina	.85
Organic matter	Traces.
Total	3.00

The water is remarkably pure, soft, and wholesome, and well adapted for the table. It is also recommended for dyspepsia and as a mild stimulating beverage in inflammatory, renal, bladder, and genito-urinary complaints. *James K. Crook.*

KEY WEST, FLA. See *Florida.*

KICKAPOO MAGNETIC SPRINGS.—Warren County, Indiana.

POST-OFFICE.—Kickapoo. Private inn.

LOCATION.—These springs are located on the line of the Chicago and Eastern Illinois Railroad, four miles northeast of Attica. The scenery about the springs is delightful, and abounds in historic interest. They are situated in a valley, on either side of which mounds rise to the height of fifty or sixty feet. Between the mounds run picturesque ravines, whose precipitous walls, composed in some places of soapstone, in others of gray or brown sandstone, show by their transverse marking the course of the ancient river as it flowed in torrents down the hillsides from the stranded and rapidly melting icebergs during the glacial period of our world's history. Among the objects of interest in the neighborhood may be mentioned Pine Creek, a romantic stream flowing through a deep valley, which is walled by towering cliffs of sand-rock, crowned by evergreen pines, cedars, and junipers, combining scenery at once grand, wild, and beautiful. This creek was used as a strong line of defence by the confederated Indian tribes prior to the battle of Tippecanoe in 1811. A number of picturesque cascades, from thirty to one hundred feet in height, are to be seen in the immediate neighborhood.

It is said that the principal spring was discovered by the Kickapoo Indians as early as June, 1750. The water was analyzed in 1885 by H. A. Huston, of Purdue University, assistant State chemist, with the following result:

ONE UNITED STATES GALLON CONTAINS:

Solids.	Grains.
Calcium carbonate	12.35
Magnesium carbonate	5.38
Ferrous carbonate	.05
Silica	.68
Sodium sulphate	.99
Sodium carbonate	.36
Organic and volatile matter	4.61
Total solids	24.42

The flow of water from this spring is about fifteen hundred gallons per hour, having a temperature of 50° F. The water is a very good antacid and diuretic. In large quantities it is said also to have a mild cathartic action. It is useful in flatulent dyspepsia with acid eructations, in irritability of the bladder and prostatitis, and in rheumatism. A peculiar black mud deposited near the springs is also used for bathing purposes.

James K. Crook.

KIDNEYS, ANATOMY AND PHYSIOLOGY OF.—I. ANATOMY.—The kidneys are bean-shaped organs situated on either side of the spinal column. They are usually said to lie in the lumbar region but are really intersected by the horizontal and vertical planes which separate the hypochondriac, lumbar, epigastric, and umbilical regions from each other and may therefore be said to lie in all these segments of the abdominal space. They lie on the fascia of the M. quadratus lumborum and on the verte-

bral portion of the diaphragm and extend from the first or the third lumbar vertebra to the eleventh rib or even higher. The left kidney is usually somewhat higher than the right.

The kidney presents two surfaces, two borders, and two extremities. The surfaces are ventral and dorsal, the ventral surface being more convex than the dorsal. The external border is convex, while the internal border is fissured by the hilum. The upper extremity is usually larger than the lower and is usually somewhat nearer to the median line.

The kidneys are usually of a flattened oval shape with the long diameter nearly parallel to the vertebral column. The form is, however, very variable. The kidneys may be slender, the length being three times the breadth and the convex and concave borders almost concentrically curved, or they may be short and broad, the vertical diameter being only a little greater than the transverse. More rarely the kidney may appear as an almost elliptical disc. In this case the place of entrance of the vessels is crowded toward the posterior surface. The sagittal diameter (thickness) is generally in inverse ratio to the transverse. The left kidney is usually higher, narrower, and thicker than the right. The vertical diameter of the kidney averages 12 cm., the transverse 6 cm., and the sagittal 3.5 cm. The volume is from 100 to 175 c.c., averaging 135 c.c. (Krause). The weight of a normal kidney varies between 90 and 180 gm., the left being 5 to 7 gm. heavier than the right. The kidneys of males are ordinarily heavier than those of females. The weight of the two kidneys is to the weight of the body as 1 to 240.

The hilus renalis is a longitudinal cleft with anterior and posterior lips, the posterior usually projecting nearer to the median line than the anterior. Between the two lips pass the renal vessels and nerves, the duct, and a quantity of fat-bearing connective tissue. The sinus renalis is flattened in the sagittal diameter, bounded by an anterior and a posterior wall, having circular or elliptical sharp borders. It extends mesially to the hilus and repeats the external contour of the kidney. The sinus contains a mass of adipose tissue in which are embedded the branches of the blood-vessels and excretory duct. It gives attachment to the primary branches (calices) of the duct.

The kidneys are covered on the anterior surface by the peritoneum. The entire organ is enveloped and supported by a capsule of connective tissue containing a larger or smaller amount of adipose tissue. This is known as the capsula adiposa. The fat in this capsule may be so poorly developed that the sheath may be mistaken in operations for peritoneum or fascia, or it may be excessively developed. The organ with its fatty capsule may normally be easily stripped off from the posterior wall, the adipose tissue being but loosely attached. In some cases the attachment becomes impaired, as a result of injury or strain, the kidney is loosened from the abdominal wall, being held in position only by the renal vessels. This gives rise to the phenomenon known as movable kidney, palpable kidney, or floating kidney. This condition is most common in women and can be determined by bimanual palpation. The left hand is placed in the lumbar region behind the eleventh and twelfth ribs, the right hand in the hypochondriac region just under the edge of the liver. In rare cases, the kidney may be surrounded by peritoneum and be held in position by a mesonephron.

The lower edge of the left kidney is usually nearly 5 cm. from the iliac crest, a little below the level of the second lumbar spine; that of the right is generally from 1.25 to 2 cm. lower. The right kidney is covered in front by the descending duodenum and flexura coli dextra, while the liver with its *impressio renalis* often covers a considerable portion of the upper part. In front of the left kidney is a part of the posterior portion of the stomach, and the *flexura coli sinistra.* The external margin of the left kidney is partially covered by the spleen. The adrenals cover the upper extremities of both kidneys, projecting a little over the anterior surface and mesial border.

The kidney is surrounded by three sheaths, an outer fatty sheath, a middle fibrous sheath and an inner muscular layer. The outer sheath, or *capsula adiposa* consists of loose connective tissue, containing an amount of fat which varies with the nutritive conditions of the body. It is loosely connected to the middle sheath, which consists of a thin but firm layer of fibrous tissue, which can be easily peeled off from the healthy kidney, leaving a smooth surface and causing but little hemorrhage when undertaken during a renal operation. This capsule consists of two layers which are easily separated, the outer 0.1 to 0.2 mm. in thickness which fuses in the sinus renalis with the connective-tissue sheaths of the blood-vessels. The inner and thinner layer continues to the point of attachment of the calices. Under this inner layer is a thin layer of smooth muscle fibres, which form a network, whose meshes are about equal in size to the diameter of the larger superficial veins. From this plexus fine processes enter the substance of the kidney.

After the removal of the capsules, the outer surface of the kidney usually appears smooth, reddish-brown in color, and of firm consistency. The color and consistency, however, vary with the blood content. Exceptionally the outer surface is traversed by shallow furrows, the remains of the lobulation of the fœtal kidney, which is distinctly marked in the kidneys of the new-born infant. The inner surface bordering on the sinus renalis is also smooth in the neighborhood of the entrance of the sinus, but presents some transverse furrows on the anterior lip, the impressions of the arteria renalis. The hilum is merely an orifice opening into the cavity of the sinus renalis. This sinus is from 10 to 12 mm. in diameter and from 30 to 35 mm. deep. In the deeper portion of the sinus the surface is uneven, presenting low, pyramidal projections with flat or rounded summits. These are the papillæ renales, of which there are from four to thirteen, generally seven or eight quite uniformly distributed over the anterior and posterior walls. The papillæ may be simple, or several may be fused into a single papilla having a larger base and furrowed sides. The simple papillæ are about 8 mm. in height, the bases having a diameter of 6 to 10 mm. Near the base of each papilla is fused the circular edge of an end branch of the ureter, a so-called renal calyx, so that the papilla forms the base of the calyx, its apex projecting into it. Numerous blood-vessels penetrate the inner surface of the kidney above the neck of the papillæ and thus outside of the calices; these are often arranged concentrically about the base of the papilla.

On section of the kidney through the hilum, the parenchyma is seen to be composed of two essentially different structures, the medulla and the cortex. The medulla consists of a variable number (eight to eighteen) of conical segments called pyramids of Malpighi, the apices of which project into the sinus and are surrounded by the calices, while the bases of the pyramids are turned toward the surface of the kidney and are surrounded by the cortex. The pyramids are smooth and glistening and present, even to the unaided eye, a longitudinal striation, indicating the course of the collecting tubules. The apex or papilla when viewed with a low-power lens presents numerous apertures, the foramina papillaria, through which the secretion escapes into the duct. The cortex may be divided into two portions: a peripheral layer, the cortex proper, which extends in a layer 5–7 mm. in thickness over the entire surface of the kidney between the bases of the Malpighian pyramids and the fibrous capsule, and an interpapillary portion, the columnæ Bertini, dipping down between the Malpighian pyramids to the bottom of the sinus, where they are covered by the fibrous capsule and more or less adipose tissue. The cortical substance is granular, grayish in color, varying however with the blood content, and characterized especially by the occurrence at quite regular intervals of red points visible with the unaided eye; these are the so-called glo-

meruli, consisting of coils of fine capillaries. At quite regular intervals processes extend from the bases of the Malpighian pyramids toward the outer surface of the kidney. These have the color and the striated appearance of the medullary substance and are known as pyra-

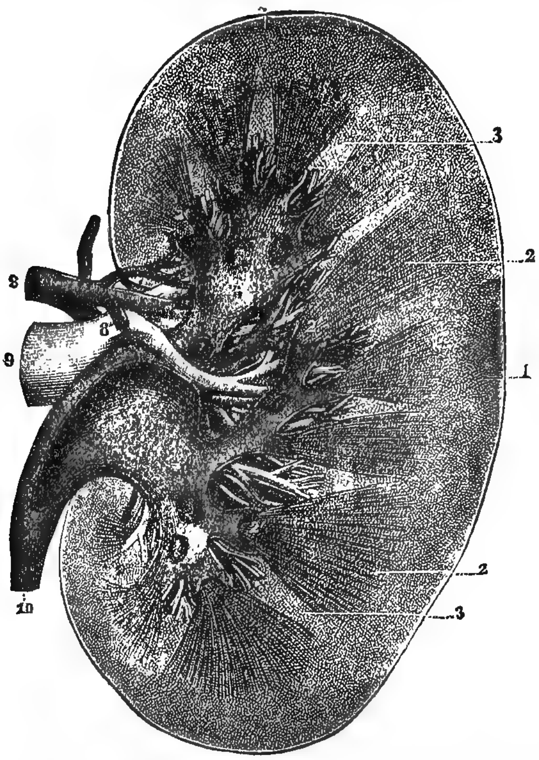

FIG. 3053.—Median Section of the Right Kidney Showing the Renal Pelvis, Papillæ, Calices, with Blood-vessels and Ureter; also the general Structure of Kidney. 1, Cortical substance; 2, pyramids of Malpighi, with two papillæ; 3, columns of Bertini; 4, pelvis; 5, calyx; 6, papillæ situated in a plane anterior to that of the section; 7, section of a calyx receiving the papilla of a pyramid in the segment posterior to the section; 8, renal artery with 8′ its posterior branch; 9, renal vein; 10, ureter. (Testut.)

midal processes or medullary rays or pyramids of Ferrein. Pyramidal processes also extend from one pyramid to another through the cortical substance which separates the pyramids.

The calices open into the expanded pelvis of the kidney, which is continuous with the ureter, the excretory duct of the kidney.

Various anomalies of form and structure of the kidneys have been described. The form of the kidneys, as previously stated, may be markedly different from the typical form described. They may be unequal in size, one being small, while the other is compensatingly large. One kidney may be lacking, the other occupying the normal position on one or the other side. As a very rare anomaly, the occurrence of three kidneys has been reported. In this case, the supernumerary kidney is either lateral or median. Numerous cases have been reported in which the ureter on one or the other side was double. In some cases the two ureters were separate throughout their entire length, opening separately into the bladder, while in other cases the two fused after an independent course varying in length. The position of one or both of the kidneys may be changed; they may encroach upon the iliac fossa, or even enter the pelvis in front of or behind the rectum; or the organ may lie upon the vertebral column or even cross to the opposite loin. The two kidneys may be fused; if only the lower extremities are fused, this phenomenon results in the formation of the horseshoe-shaped kidney, which is usually median in position. In other cases the mass consisting of the fused kidneys is on one or the other side and varies in shape. In the case described by McMurrich, the fused mass occupied the left side, the left kidney being fairly normal in shape, while the right was discoidal in shape and had crossed over and fused with the anterior surface of the left. A ureter arose from each portion of the mass passing downward and opening into the bladder in the normal position. While the anterior surface showed the line of demarcation between the two kidneys, the posterior surface was smooth and showed no indication of a separation. Only twenty-eight similar cases have been recorded. The variations in motility, with the phenomena of palpable and movable kidney, have already been mentioned.

On microscopic examination the kidney is seen to be composed of numerous twisted and convoluted tubules known as the uriniferous tubules. Each tubule begins in the cortex of the kidney between the medullary rays in an enlarged, expanded, cup-shaped portion called the capsule of Bowman, which surrounds the glomerulus, the two together bearing the name of the Malpighian corpuscle. The capsule of Bowman opens through a narrow neck into a larger convoluted portion, called the proximal convoluted tubule. After describing many tortuous windings, the tubule passes in the form of a straight, slender tubule toward the sinus. After going a variable distance into the medullary substance it turns sharply, describing a loop and returns into the cortex in a larger straight tubule running parallel to the descending limb of the loop. The small descending limb, the loop, and the larger ascending limb have collectively received the name of the loop of Henle. The tubule then becomes somewhat larger and somewhat twisted (the distal convoluted tubule or the intercalated portion) and then passes into the arched collecting tubule. This changes into the straight collecting tubule, many of which unite as they pass downward into the medullary pyramid to form the large collecting tubules or tubes of Bellini. The capsules, the neck, the proximal and distal convoluted portions of the uriniferous tubules and the arched collecting tubules are found in the cortex between the medullary rays. The medullary rays are formed by the cortical portions of the collecting tubules and a portion of the ascending limbs of the loops of Henle. The medulla is made up mainly of straight collecting tubules of various sizes and of the descending limbs and loops of Henle's loops, the latter being often found in the boundary zone between cortex and medulla. The different portions of the tubules vary markedly in size, the Malpighian corpuscle measuring 120 to 220 μ in diameter, the proximal convoluted tubule from 40 to 70 μ in diameter, while the loops of Henle present tubules having a diameter of 9 to 15 μ in the descending limb and 23 to 28 μ in the ascending limb. The distal convoluted portion is from 39 to 45 μ in diameter, while the collecting tubules vary from 45 to 75 μ in diameter. The tubes of Bellini unite in the Malpighian pyramids to form about twenty papillary ducts from 200 to 300 μ in diameter which empty into the pelvis of the kidney through the foramina papillaria.

The character of the epithelium lining the uriniferous tubules in the different portions varies markedly and has been subjected to most careful histological investigation. The epithelium of the capsule of Bowman, which forms a double-walled membrane around the glomerulus, leaving a cleft-like space which forms the beginning of the uriniferous tubule and communicates with the lumen of the proximal convoluted tubule, is simple squamous in type. The glomerular epithelium is very flat, with nuclei projecting slightly into the lumen, while that lining the outer wall of the capsule is somewhat higher, but still distinctly squamous in type. The flattened epithelium of the capsule changes gradually into cubical epithelium of the neck and that into short and rather irregular columnar epithelium of the proximal convoluted tubules. These cells show a basal striation and often a cuticular border, and, as the investigations of Nussbaum

and Heidenhain seemed to show that they were especially concerned in the process of secretion in the kidney, these cells have been subjected to most searching study, with the view of determining the structure of the cells and the changes of structure during the process of secretion. Henle showed that the epithelium of this portion of the uriniferous tubule is characterized by a dark, granular appearance of the protoplasm, while Krause mentions the basal striation of these cells. A zone of short stiff cilia was demonstrated in certain renal cells of amphibia and fishes by Nussbaum, the observation being extended to mammalia, including man, by Cornil, Tornier, Klein, and others. This zone is characterized by Tornier as the *Bürstensaum*. Since this zone was not always found and when present was always connected with a certain thickness of epithelium found in different kidneys and different areas of the same kidney, the conclusion was drawn that the cells undergo uniform histological changes during the processes of secretion. Van der Stricht says that the resting cell presents a homogeneous cuticular zone, below which is a close-meshed protoplasmic network, which shows a parallel arrangement of its fibrils in the peripheral portion of the cell, producing the "rod structure" of Heidenhain. When the secretion begins, clear droplets of secretion form, especially in the neighborhood of the nucleus, which press toward the free surface, fill the formerly homogeneous cuticular zone and break it up into the "Bürstensaum." In a later work, Van der Stricht describes four types of cells in the convoluted tubules: (1) Cells like those above described, which he regards as resting cells; (2) cells with the Bürstensaum, in the protoplasmic network of which the secretion is in the form of fine droplets, especially toward the lumen; (3) cells without a cuticular border also filled with the secretion; (4) granular cells with distinct rod structure in the peripheral portion of the cell, while the central portion is changed into a clear mass filled with granules. Such cells are also found in the ascending limb of Henle's loop together with cells which have a distinct cuticular border. Van der Stricht also describes in the glomerular epithelium during the process of secretion the collection of clear droplets with processes in the protoplasm of the cells. Disse, working on fresh, well-fixed human tissue, distinguished four forms of tubules: (1) Tubules with wide lumen and low, quite uniformly granular epithelial cells in which cell contour and rod structure cannot be distinguished. The free surface shows the Bürstensaum distinctly developed, formed of stiff hairs provided with nodular thickenings at their bases. (2) Tubules with narrow cylindrical lumen and spherical epithelium. The protoplasm is still generally uniform, but in some cells clearer parts begin to be seen giving the cell a spotted appearance. The Bürstensaum is wanting. (3) Tubules with narrow, irregularly star-shaped lumen and tall cells. In these, two portions are distinguished, a central clear part containing the nucleus, and a darker basal portion in which rows of fine granules begin to produce the picture of the "rod structure." No Bürstensaum is seen in these cells. (4) Tubules entirely filled by the tall epithelial cells, which show a distinct differentiation of the central and basal portions. The nucleus in the central portion of the cell is very bright and clear and resembles a vesicle filled with clear fluid. Rod structure is very distinct in the basal portion of these cells, but no Bürstensaum is to be seen. Sauer, however, states that the secretory portions of the uriniferous tubules have the same type of epithelium, while the lumina naturally are subject to great variation. The striation of Heidenhain and the peculiar terminations of Tornier were found by him in all phases of secretion, being finer or coarser according to the height of the cells. Hence he concludes that these peculiarities of structure have nothing to do with the processes of secretion, but are permanent structural appearances. The nucleus seems not to suffer any changes of structure during secretion, although changes of position have been observed. It ascends toward the free surface of the cell with the secretion, returning toward the basal portion of the resting cell. Disse concludes that, as signs of proliferation are never seen in these cells in the adult, the cells do not degenerate after secretion. Rothstein describes an irregular branching and interlocking of the processes of the cells of the convoluted tubules in the dog and rabbit, giving to these cells a peculiar frayed-out appearance similar to that described for these cells in the guinea-pig as mentioned in the text-book of Böhm, Davidoff, and Huber. Landauer investigated these cells in many species of vertebrates and also in man and concluded that the convoluted tubules and the ascending limb of Henle's loop are lined by cells which are sharply outlined and provided with longitudinal folds, which interlock, and it is these folds that give these cells the striated appearance (rod structure of the authors). Zimmermann describes in detail the epithelium lining the different portions of the uriniferous tubules, especially emphasizing the presence and relations of the "Centralkörper or Centralgeissel" in these cells. He also distinguishes the darker cells showing striation and brush-like border and cells which are large and clear, the structure of which is quite indistinct. He describes fine densely placed fibres

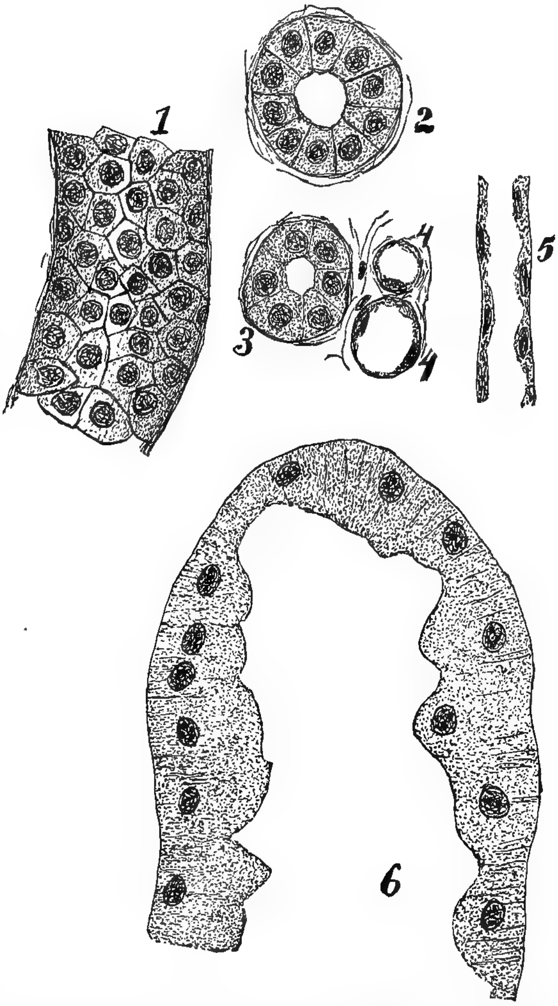

FIG. 3054.—Epithelium of Kidney. 1, Collecting tube viewed in longitudinal section; 2, transverse section of collecting tube; 3, ascending limb of Henle's loop; 4, descending or narrow limb of Henle's loop; 5, longitudinal section of descending limb; 6, convoluted tube.

staining black in the iron-lake hæmatoxylin, which run circularly around the tubuli contorti between the bases of the cells and the basement membrane. He was unable

to decide, however, whether these were special kinds of fibres, or cell processes or basal lines of cement substance. The descending limb of Henle's loop is lined by flattened

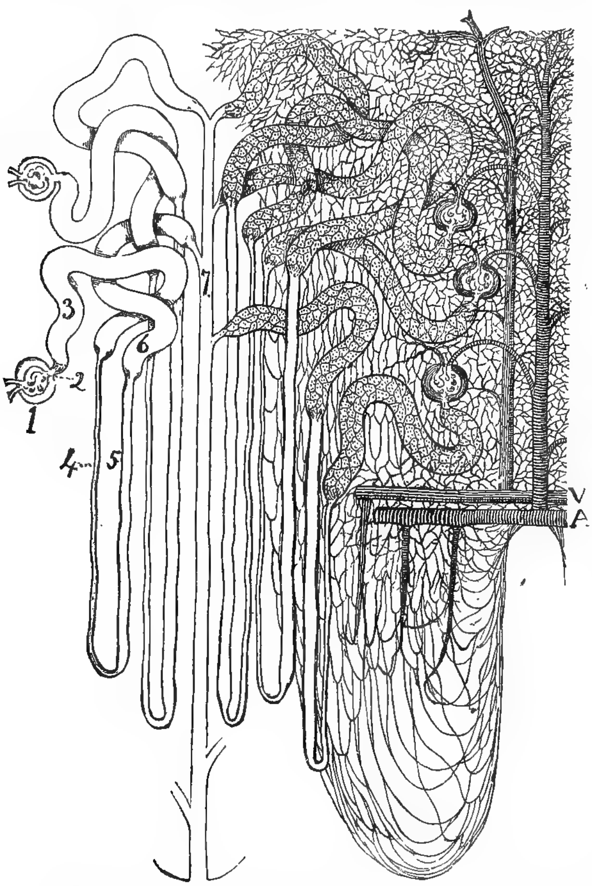

FIG. 3055.—Diagram of the Renal Tubes and Circulation. 1, Malpighian body; 2, neck; 3, proximal convoluted tube; 4, descending limb of Henle's loop; 5, ascending limb; 6, distal convoluted tube; 7, collecting tube; *A*, artery; *V*, vein. An intralobular artery is shown ascending and giving off branches to the tufts; the straight arteries descend; the intralobular vein is shown commencing as a stellate plexus on the surface.

cells, with nuclei projecting slightly into the lumen, the nuclear projections of the two sides alternating, thus giving to the section a wavy appearance. The cells of the loop and of the ascending limb are higher and approach the columnar type of the convoluted tubules. In the intercalated portion, the epithelium closely resembles that in the proximal convoluted tubule, while the lining of the arched collecting tubule is cubical in type. The epithelium of the straight collecting tubules is low columnar at first, increasing in height as the tubules increase in size. The pelvis of the kidney, as well as the ureter, is lined by a stratified transitional epithelium, like that in the bladder.

Under the epithelium of the uriniferous tubule throughout its entire extent is a basement membrane, the character and structure of which have been investigated by Rühle, Disse, von Ebner, Mall, and others. Mall's investigations were carried on largely by pancreatic digestion and subsequent staining in acid fuchsin and picric acid. As a result of this work, the framework of the kidney was shown to consist of white fibrous connective tissue and reticulum, Mall and Rühle describing "baskets" of reticular fibrils as surrounding the tubules and forming the basement membranes. Disse and von Ebner, however, refer the fibrillar appearance to the methods of preparation, and Mall, in his latest work on these membranes, demonstrates clearly within the "basket" of connective-tissue fibrils previously described, a homogeneous membrane which was destroyed by pancreatic digestion and which is chemically different from the reticular tissue and also from both white fibrous and yellow elastic connective tissue.

Between the tubules is found a small amount of connective tissue, which is more abundant around the blood-vessels and Malpighian corpuscles, near the junction of cortex and medulla and between the collecting tubules in the apices of the Malpighian pyramids.

Blood Supply of the Kidney.—The kidney receives a very rich blood supply, and the arrangement and distri-

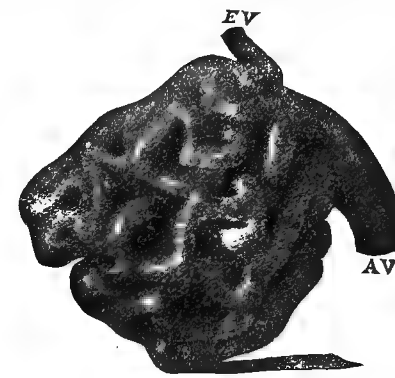

FIG. 3056.—Wax Model of Glomerulus of Human Kidney. Enlarged 444 diameters, seen in profile from the left side. *A V*, Afferent vessel; *E V*, efferent vessel.

bution of its blood-vessels are of the utmost importance both from a physiological and from a surgical point of view. The main arterial supply is from the renal artery, a branch of the abdominal aorta. Collateral branches, however, reach the surface of the kidney through the capsule, arising from the suprarenal, spermatic, lumbar, and other arteries.

The renal artery divides at the hilum into anterior and posterior branches, which redivide and pass through the columns of Bertini between the pyramids of Malpighi to the border of cortex and medulla. Here the branches unite to form an arch known as the arcus arteriosus. From the convex border of this arch, ascending or intralobular arteries arise to supply the glomeruli and also to pass through the cortex and supply the capsules of the kidney. From the concave border, branches known as the vasa recta pass down into the medulla, between

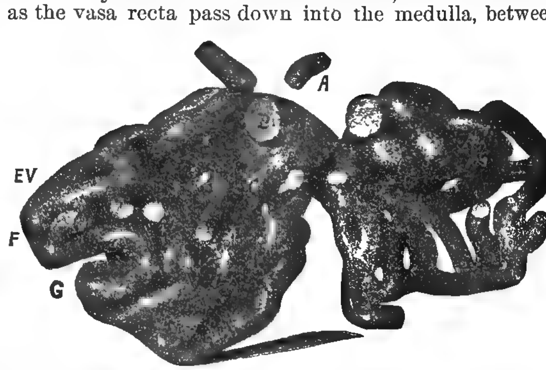

FIG. 3057.—Wax Model of Glomerulus. Same enlargement and view as Fig. 3056. The left lateral group of capillaries is separated from the median group and turned back, exposing the interior of the glomerulus, *A*. A short section of a capillary of the median group is removed to show the course of the deeper lying capillaries. (Johnston.)

the straight collecting tubes of the pyramids, breaking up into capillaries around these tubes. The intralobular arteries in the cortex send branches to the glomeruli, the arteriæ glomeruliferæ, the afferent vessels entering

the glomerulus and dividing into several branches, which redivide and break up into a network of anastomosing capillaries, as described by Johnston. This arrangement is shown diagrammatically in Fig. 3058 and more exactly

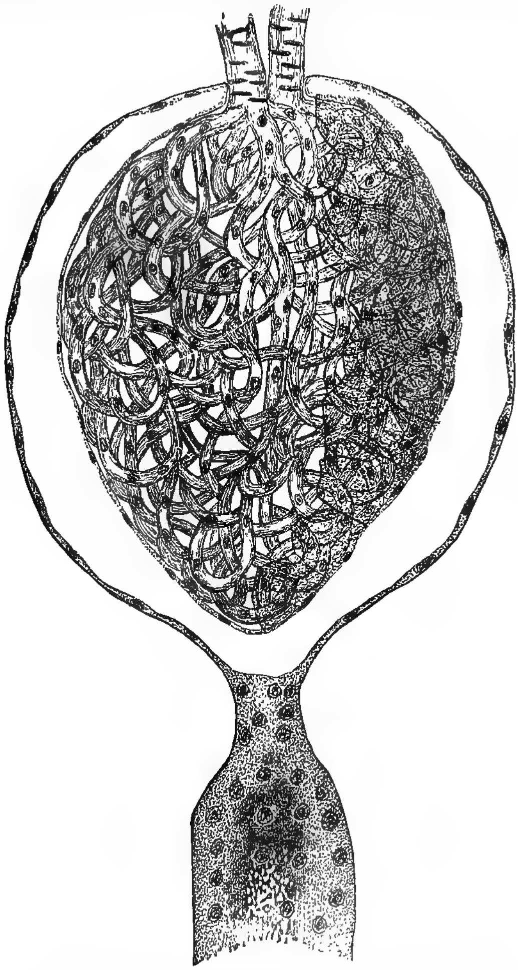

FIG. 3058.—Diagram of a Malpighian Body Showing the Afferent and Efferent Vessels above, with the Tuft. The reflection of the cells of Bowman's capsule over the vessels is shown on the left; on the right, the cells are shown in the flat; the neck and part of a convoluted tube are shown below. The space between the tuft and the capsule is drawn wider than normal.

in Figs. 3056, 3056, representing Johnston's models of the human glomerulus. He describes a network of reticular tissue arising from the membranes surrounding the glomerulus and forming the framework of the glomerulus in the meshes of which are found the capillaries and fine branches of the afferent artery. The blood collects into small branches which unite to form the efferent artery, which runs for a variable distance and finally breaks up into a second system of capillaries around the convoluted tubules. The intralobular vessels open into the glomeruli only after forming an arch, so that the blood passing through the glomeruli is already on its way to the medulla, and the secretion is directed, not toward the periphery, but toward the medulla and the apex of the pyramid (Zondek). Virchow thinks that this arrangement prevents the tearing of the glomeruli which might result if the blood entered them directly under the strong pressure from the aorta.

In addition to the *rete mirabile* in the glomerulus, other retia mirabilia are formed in the course of the intralobular arteries, differing from those in the glomeruli by the fact that the branches are much larger than capillaries. Some of the ascending arteries arise from the larger vessels in the columns of Bertini, before the formation of the arch; a few of the branches of the intralobular arteries do not pass to the glomeruli, but break up directly into capillary plexuses, rarely around the convoluted tubules, but more frequently in the fatty capsule. These are known as perforating arteries. In addition to the arteries arising from the renal artery in the hilum, branches from the suprarenal, lumbar, etc., penetrate the capsule and form glomeruli of their own in the peripheral portion of the cortex. These may not only assist in establishing the collateral circulation, but also may act as a partial functional substitute in case of injury to the renal arterial system. Golubew, Hoyer, and Geberg assert that between the arteries and veins of the kidney, in the cortical substance, in the columns of Bertini, and at the bases of the Malpighian pyramids, direct anastomoses exist by means of precapillary twigs.

From the capillaries, the venous blood is collected into the intralobular veins, which have an arrangement similar to that of the intralobular arteries. The venous blood of the capillaries in the labyrinth is also collected into the intralobular veins, so that at the surface of the kidney, the flowing together of these different systems of veins results in the formation of peculiar star-like figures, known as the venæ stellatæ or stars of Verheyen. The intralobular veins empty into the venous arches, which correspond in position to the arterial arches and from which the blood is carried by means of larger veins through the columns of Bertini and through the hilum side by side with the larger arteries. Venæ rectæ also collect the blood from the medulla and empty into the concave side of the venous arch.

The terminal branches of the intrinsic arteries of the kidney have recently been investigated by Zondek to determine whether the vascular supply of cortex and medulla was common or separate and by Broedel and Keiller to determine the relation of the branches in the pelvis and kidney, with especial reference to their significance in nephrectomy. Although working independently and by quite different methods, the two last-named writers arrived at nearly the same results and at nearly the same time. Broedel used, in his investigation, the Schieffer-decker corrosion method, combined with injection of the

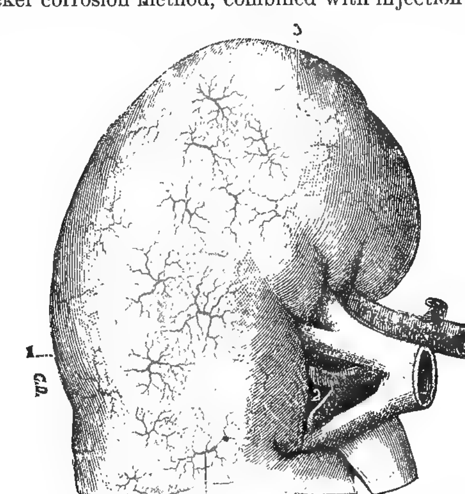

FIG. 3059.—The Venous Stars of Verheyen, seen on the Anterior Face of the Right Kidney. (Testut.) 1, External border of the kidney; 2, hilum with the renal vessels; 3, venæ stellatæ.

arteries, of the veins and pelvis, and finally triple injection of arteries, veins, and pelvis. He divides the renal pelves into true pelves, in which all the calices, major and minor, open into a common pelvis, and divided pelves, in which there is no free communication between all the calices of the kidney. He states: "The renal artery divides at the hilum, as a rule, into four or five branches,

the distribution of which, in relation to the pelvis, is such that three-fourths of the blood supply is carried anteriorly, while one-fourth runs posteriorly. The relative size of the two systems may occasionally be $\frac{4}{5} : \frac{1}{5}$, $\frac{2}{3} : \frac{1}{3}$, but rarely $\frac{1}{2} : \frac{1}{2}$. The arteries are end arteries in the strictest sense of the word and the branches of the anterior division never cross over to the posterior side and vice versa. They do not anastomose with each

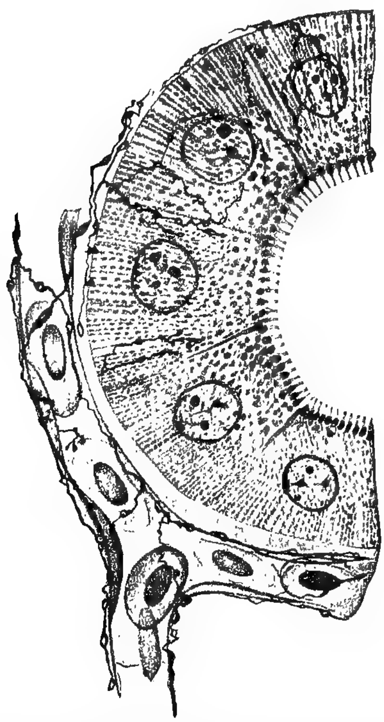

FIG. 3060.—Cross Section of a Convoluted Tubule from the Kidney of a Frog, Injected with Methylene Blue, fixed by Bethe's Method, and Counter-stained with Cochineal. In the neighborhood of the tubule are two nerve fibres, one of which passes to the wall of the tubule, while the other goes to the blood-vessel. On the epithelial cells of the tubule, varicose fibres are seen, which form free endings of different form; these epithelial nerve endings arise from nerve fibres which lie at the periphery of the tubule on the outer surface of its sheath. Around the blood capillary, varicose nerve fibres form a plexus, which forms two small endings in the walls of the capillary; one of these consists of three short fibrils and the other of two, which end in a knob. (Smirnow.)

other. To Hyrtl apparently is due the credit of having first mentioned this 'natürliche Theilbarkeit der Niere,' by which he means that in a corrosion specimen, the two arterial systems are completely separated by the pelvis. He also affirms that this arrangement of the renal arteries is found 'without exception in all mammalia from the whale to man.'"

The surgical significance of this work of Broedel's is seen in the possibility of an incision through the renal substance in the plane separating the areas supplied by these two independent systems. Concerning the veins, Broedel states: "While there is a complete arterial division in the plane connecting the posterior calices and terminating in the lateral half of the upper and lower calices, the veins follow quite a different arrangement. Around the bases of the pyramids they anastomose and form the familiar venous arches. They unite in large branches that run between the sides of the pyramids and the columns of Bertini to the necks of the calices, where they lie between the pyramid and the arterial branches. The thickness of these collecting veins accounts for the peculiar lobulated appearance of the bases and sides of the pyramids. Around the necks of the calices, both anteriorly and posteriorly, these veins form a second system of anastomoses, much shorter and thicker than that at the base of the pyramids. This appears as a number of thick loops or rings which fit like a collar around the necks of the calices. Nearly all the collected blood of the posterior region is carried anteriorly through these short thick stems, to join that of the anterior portion."

Lymph clefts have been described in the labyrinth of the kidney, especially around the convoluted tubules and around the blood-vessels, and also around the blood-vessels of the capsules and of the medullary portion of the kidney. These unite into true lymph vessels, which are divided into superficial and deep. The former arise on the surface of the organ, as their name indicates, and pass toward the hilum. The deep vessels accompany the blood-vessels toward the sinus, where four or five are usually found, one for each division of the artery. They, with the superficial lymph vessels, pass to the lumbar lymph glands which are nearest to the hilum.

Stahr has recently reported the results of some work on the lymph apparatus of the kidney. He found two systems of capillaries in the capsule: one in the fatty capsule (superficial) and one in the fibrous capsule, connected to the lymph capillaries of the cortex. He finds no lymph capillaries in the glomeruli. The capillaries of the cortex, like the blood capillaries, form a network and collect at quite regular intervals in the medullary rays and pass down vertically to the border of cortex and medulla, where they form arches. These arches are in communication with the lymph vessels, which pass straight through the medullary substance.

Nerve supply of kidney. The nerves of the kidney are derived mainly from the sympathetic through the solar and aortic plexuses, the semilunar ganglia and the splanchnics. They communicate with the spermatic plexuses, and some filaments have been traced to the pneumogastrics (Morris).

The mode of distribution and termination of the nerves in the kidney has been investigated by Retzius, Kölliker, von Ebner, Berkeley, and many others. Smirnow has quite recently reported the results of his extensive investigations on these nerves by means of the Golgi method and the Ehrlich methylene blue method. He states that the nerve trunks enter the sinus renalis, partly with the blood-vessels and partly accompanying the renal ducts. These trunks consist of non-medullated nerves and medullated nerves of different calibre. These nerves form a plexus in the sinus renalis, in the meshes of which he was able to demonstrate multipolar nerve cells. He describes motor nerve endings in the smooth muscle of the walls of the renal pelvis and of the ureters, sensory free endings in the connective tissue of these structures and also interepithelial fibres. In the fibrous capsule numerous nerve fibres were found which ended partly on the blood-vessels, in which both motor and sensory endings were observed, and partly in the connective tissue. All the blood-vessels of the kidney are provided with nerves, in many of them both motor and sensory nerve endings having been observed. From the plexus in the vasa afferentia, non-medullated nerve fibres penetrate into the glomerulus, ending partly on the capillary vessels of the glomerulus and partly in free endings on the outer surface of Bowman's capsule. In addition to the nerves supplying the blood-vessels of the kidney, there are also nerves arising from trunks which accompany the arteries, which end on the urinary tubules of both the cortex and medulla. There is a close anatomical relation between the nerves of the renal parenchyma and the vascular nerves. The urinary tubules of both cortex and medulla are provided with non-medullated nerves, which run in the sheath of the tubules, branch repeatedly, forming a plexus on the outer surface of the membrana propria of the tubules. From this plexus varicose fibres arise, which end on the surface of the membrana propria (epilamellar nerve endings). From the epilamellar plexus, fine fibres arise, which pass through the membrana propria into the tubule and form, on the surface of the epithelial cells, endings of different form (hypola-

mellar endings). These are found in the convoluted tubules, in the straight collecting tubules, and in the main excretory ducts of the kidney. The mode of ending of the nerve fibres and the relation of the vascular and secretory nerves are shown in Fig. 3060 taken from Smirnow's report.

Thus the kidney is shown to have a large number of nerves and nerve endings, from which we must conclude that the nervous system exerts a constant influence on the excretion of the urine.

Development of Kidney.—The development of the kidney is associated with the development and degeneration of certain fœtal structures, known as the pronephros and the mesonephros. The former originates in the cells of the middle plate and consists of a long tube, the pronephric duct, and transverse tubules, which open into the pronephric duct and communicate with the body cavity. These are invaginated by glomeruli. This organ functionates as an excretory organ in certain of the lower forms, but in man it either does not occur or is very primitive. The mesonephros, or primitive kidney or Wolffian body, is established on the part of the pronephric duct, immediately behind the pronephric tubules, and consists of a duct, the mesonephric duct, which grows backward from the pronephric duct and opens into the cloaca, and a number of transverse tubules originating in the nephrotomes. The transverse tubules are in communication with the body cavity and later connect with the the Wolffian duct, while the central portion becomes sacculated and then invaginated to form the primitive Malpighian corpuscles. This organ develops in man by the seventh week and retrogression begins in the eighth week, the Malpighian bodies having disappeared by the fifth month.

The permanent kidney or metanephros begins to develop as early as the fifth week of embryonic life. From the cloacal end of the mesonephric duct an evagination grows forward into the mass of mesoblastic tissue known as the blastema and forms the anlage for the ureter. From the extremity of the ureter, tubules bud out, become elongated and convoluted, and the extremity invaginated by the mesoblastic tissue, which forms the blood-vessel and connective tissue of the organ. Two distinct views are expressed in the literature regarding the development of the permanent kidney: one is that the pelvis of the kidney, collecting tubules and uriniferous tubules all develop from this evagination from the mesonephric duct. This view is upheld by Müller, Remak, Kölliker, Schweiger-Seidel, Toldt, Nagel, Minot, Gerhardt, Haycraft, Heisler, and others. This view is well summarized by Haycraft. He states: 1. That the connective tissue and blood-vessels of the kidney develop from the blastema, while the epithelium of the tubules proliferates from the cells originally lining the ureter and Wolffian duct.

2. The tubules which first sprout into the blastema terminate in dilatations, the primary renal vesicles.

3. Then these form branching cavities which always remain at the periphery of the cortex; from these the urinary tubules bud off, the older ones sinking down into the medulla.

4. The tubules which first sprout from the ureter soon become turned inside out to form the pelvis of the kidney.

5. Many of their prolongations into the rapidly dividing renal vesicles also become evaginated, thus increasing the number of tubules passing between the pelvis and the renal vesicles at the cortex.

6. Those that remain form the collecting tubules.

7. The Bowman's capsule is moulded into its shape upon the bent tubule long before the glomerulus is formed. It is invaginated rather by its tubule than by the glomerulus.

The second view is strongly supported by Kupffer, Gegenbaur, Wiedersheim, Hamburger, Schreiner, Chievitz, and Herring. Herring thus summarizes the views held by these authors: The kidney arises from two distinct structures which come together at an early period and remain intimately associated during further development.

1. *The Kidney Blastema.*—This consists of a mass of cells closely related to the blastema of the Wolffian body, and apparently formed from the intermediate cell mass or the peritoneal epithelium. It is therefore mesoblastic. It forms an envelope around the ends of the ureter branches, and persists as a thin cellular investment under the capsule and between the lobules, until the end of the eighth month, after which it entirely disappears.

2. *The Ureter.*—This structure is an outgrowth from the Wolffian duct. It appears at the end of the first month, and grows forward, as a solid column of cells, to reach and embed its peripheral branches in the kidney blastema. The balance of recent opinion is in favor of the ureter being epiblastic.

At the beginning of the second month, the ureter has come into apposition with the kidney blastema and the result is the beginning of the formation of the permanent kidney. The ureter branches early, and its lumen dilates anteriorly to form the future pelvis and calices. The primary branches are of a definite number, and at their extremities masses of cells appear constituting the "Nierenbecke" of the German writers. From these masses of cells in the kidney pelvis are developed the collecting tubules of each lobule. Ureter, pelvis, calices, and collecting tubules are formed from the Wolffian duct and these are the only parts formed from this structure, unless we include part of the intercalated tubule. From the kidney blastema arise the Malpighian bodies, convoluted tubules, Henle's loops, and the junctional tubules, the connective-tissue framework and the capsules. Malpighian bodies and their tubules begin to appear at the end of the second month, uniting at an early stage with the branches of the ureter. Each Malpighian body with its tubule arises as a solid mass of cells at the periphery of the lobule in close relation to the dilated extremity of a branch of the ureter. The solid mass acquires a lumen and assumes an S-shape. The lower limb of the S becomes a Malpighian body, the upper and middle limbs become convoluted tubules, while the bend between them develops into the Henle's loop; the extremity of the upper end joins the collecting tubule and forms the greater part of the junctional tubule. The cells lining the tubules are at first similar, but become differentiated as the organ functionates.

Schreiner, in the last number of the *Zeitschrift für wissensch. Zool.*, gives an extensive report on his work on the development of the kidney in which he studies thin serial sections, also reconstructing the developing kidney at different stages of development, and reaching conclusions very similar to those just quoted from Herring.

Both views are so strongly supported and the decision seems so difficult to make, that more work and by other methods than those that have been used seems to be necessary; however, the careful and decisive work of Kölliker, Minot, Golgi, and Haycraft, as well as analogy with the mode of development of other glandular structures of the body, seems to make the conclusion undeniable that all the glandular portion of the kidney is developed from the one anlage derived from the mesonephric duct. The groups of cells of the blastema, described as forming the uriniferous tubules, no doubt form the connective-tissue stroma and blood-vessels of the organ.

II. Physiology of the Kidney.—Two portions of the kidney have been regarded as of primary physiologic importance and have therefore received most exhaustive study—a study which has resulted, however, in views which are most widely divergent. These two portions are the glomeruli, including the capsule of Bowman, and the convoluted tubules, including the loops of Henle. As stated under the Anatomy of the Kidneys, the glomeruli consist of branching and anastomosing loops of capillaries, between which is a small amount of reticular connective tissue, the entire structure being imperfectly divided into lobules by strands of connective tissue. The glomerulus is covered by a single layer of much flat-

tened epithelial cells, the glomerular portion of Bowman's capsule. Between this and the peripheral portion of the capsule is a space, which connects with the lumen of the uriniferous tubule and hence forms the beginning of this structure. We have therefore a structure analogous to that of the lungs. The blood is found in thin-walled capillaries, separated from the urinary space only by the thin wall of the capillary and a single layer of flattened epithelium—the typical condition for osmosis. The endothelium-like cells of Bowman's capsule have been carefully studied with the view of determining whether any changes of structure of these cells occur during the process of secretion, and Van der Stricht states that clear droplets of fluid have been seen by him in these cells between the granules of protoplasm. The cells lining the convoluted tubules and loops of Henle have been studied by various methods by Heidenhain, Henle, Krause, Nussbaum, Tornier, Van der Stricht, Zimmermann, Sauer, and many others. The rod structure, ciliated border (Bürstensaum), granular and vacuolated appearances of the cells have been described somewhat in detail under the Anatomy of the Kidney and need not be repeated here. Nicolas states that the inner portion of these cells is destroyed during secretion as in the cells of the mammary gland, the cells being then rebuilt from the peripheral portion of the cell. Most of these authors agree that the cells of the convoluted tubules and Henle's loops undergo certain important changes of structure, which they ascribe to the processes of secretion, the fluid being collected in the cell in the meshes of the protoplasmic network, and finally extruded into the lumen; Sauer, however, refuses to admit that the appearances described have anything to do with the processes of secretion, being found in all phases of secretion alike. These cells are in many respects like the cells lining the intestinal cavity, which are known to be absorptive rather than secretory in their function; the Bürstensaum is comparable to the striated cuticular border of these cells while the striated protoplasm is met in many types of cells, especially of gland ducts. The variations observed by different authors and even by the same author in different preparations may be, in part at least, due to different methods of fixation or to other differences of technique.

That certain portions of the urine are excreted by the glomeruli is admitted by all authors, but views differ widely in regard to how much, what constituents, and whether the process is purely physical, a process of filtration, or whether the glomerular epithelium is actively concerned in the process, so that it becomes a vital process of secretion. Many physiologic experiments have been undertaken to determine these points, and two diametrically opposed views have arisen, each of which is supported by a long line of investigators.

1. *The Bowman-Heidenhain Vital Theory.* — This theory was first formulated by Bowman in 1842 on a purely anatomical basis and it was later (1874) confirmed by Heidenhain on the basis of experimental data. It is briefly stated as follows:

"(*a*) In the kidney, as in all other glands, the secretion depends on the active intervention of special secretory cells.

"(*b*) The first type of these cells is represented by the simple layer of epithelium covering the glomerular loop of capillaries. The office of these cells is to secrete water and such salts of the urine as are found in all other parts of the body in watery solution (*e.g.*, sodium chloride).

"(*c*) Another system of secretory cells, forming the lining investment of the convoluted tubules and ascending limb of the loop of Henle, secrete the specific constituents of the urine (urea, uric acid, etc.).

"Under some conditions, they may also secrete a certain amount of water.

"(*d*) The activity of the two kinds of secretory cells is determined: (1) By the amount of water or urinary constituents contained in the blood; (2) by the velocity of the blood flow through the capillaries of the kidney, inasmuch as on this factor depends the supply of oxygen and of substances to be secreted to the cells.

"(*e*) The great variability in the constitution of the urine may be explained by differences in the secretory activities of these two types of cell."

Heidenhain based his conclusions largely on the fact that after the injection of indigo carmine, the cells of the convoluted tubules and of the ascending limb of Henle's loop were colored by the dye, while the other portions of the kidney were quite free from the pigment. In the kidneys of birds, crystals of uric acid were found in the same cells by Bowman and v. Wittich, while indigo carmine, carmine, Ehrlich's tricolor mixture, and other dyes have been used by other investigators with similar results.

Dreser concludes from his observations that the production of urine is attended by the doing of work on the part of the kidney and must therefore be looked upon as a process of secretion, while Adami states that the glomerular epithelium must be looked upon as possessing powers of a selective secretory nature. Thompson decides from his experiments with atropine and morphine that the production of urine is to a certain extent analogous to the manufacture of the secretion of other glands which are influenced by atropine. Magnus and Gottlieb conclude from their experiments with diuretics that, while there is usually an increase in the blood content of the kidney, shown oncometrically, as a result of the administration of diuretics, yet diuresis may occur without a corresponding increase of the blood flow through the kidney. The increased flow of blood is regarded as an auxiliary factor in the increase of the secretion, and the diuresis may be checked by causing contraction of the renal arterioles. From these data, they conclude that "the relations between the circulation and excretion in the kidney are similar to those in the salivary glands."

2. *Ludwig's Mechanical Theory.*—In 1844 Ludwig presented his well-known theory, which is briefly formulated as follows:

"(*a*) The secretion of water is a purely mechanical process, depending only on the blood pressure in the glomerular capillaries and the permeability of the filtering membrane.

"(*b*) This dilute fluid is concentrated in the tubules by giving up its water to the surrounding lymph, in consequence of differences of concentration between the glomerular fluid and the lymph.

"(*c*) All the urinary constituents are turned out of the blood with the water through the glomeruli."

This theory depends on the connection between the circulation through the kidney and the amount of urine excreted. A mechanical filtration must depend largely on differences of pressure between the blood in the capillaries and the urine in the tubules; partly also on the rapidity of the blood flow through the glomeruli.

The blood pressure is raised: (1) By a rise of the general blood pressure; (2) by dilatation of the renal arterioles, and (3) by obstruction of the renal vein. This last factor, while it raises the pressure of the blood, will also retard the blood flow and, as shown by the work of De Souza and others, causes a diminution or cessation of the urinary excretion.

The theory, so far as the absorptive function of the epithelial cells of the tubules is concerned, is confirmed by the facts mentioned by Korányi that the concentration of the urine increases with the length of the convoluted tubules and diminishes in proportion to the rapidity with which it passes through the tubules, as after diuretics, when the urine is very dilute. Dreser decides that the work of the convoluted tubules is purely absorptive, but regards this as a vital process, because of the fact that in pathologic conditions, when the cells of the tubules are diseased and incapable of doing work, the urine is more dilute. Korányi draws the conclusion that only the physical processes of metabolism are so far explained and that, while many facts still remain tending to confirm the vitalistic theory, these are becoming fewer and fewer, and the probability is that, with the further advance of our knowledge on this subject, physical processes will more and more predominate over the vital.

Kidneys.

Cushney states that the relative amounts of chloride and sulphate in the urine vary independently of their proportions in the blood plasma and also of the degree in which each is present in excess, a fact which he explains by saying that the tubules alter the glomerular fluid by absorbing some of its constituents, the sulphates being absorbed with greater difficulty than the chlorides. His experiments on diuresis have so important a bearing on the settlement of this vexed question that a fuller reference to them will not be out of place here. He, in a number of experiments, injected into rabbits solutions of sodium chloride, sodium sulphate, sodium phosphate, and urea. The urine having been examined before the experiment, mixtures of two of the solutions were injected into the jugular vein, the urine being collected and examined at frequent intervals. In the first stage of diuresis after the injection of the mixture of chloride and sulphate, the chloride of the urine was to that of the plasma as 2 : 3, while in the last phase it was in the ratio of 1:5. The sulphate in the first phase was as 2 :1, and in the last phase as 10 : 1. The only assumption necessary to explain these results is that the sulphates are absorbed by the tubules with greater difficulty than the chlorides, an assumption which is in accord with their behavior toward the epithelial cells of the intestine, red blood cells, and others. The precipitation of the carbonates in the normal urine of the rabbit is also better accounted for by the reabsorption of the solvent than by any other hypothesis. This absorption, however, he regards not as a simple diffusion, as Ludwig at first assumed, but there must be an unknown force causing a current from the lumen toward the blood as in the intestine. Which constituents of the glomerular fluid shall be subjected to this force, however, is determined by their diffusibility into the cells. The injection of urea resulted in similar phenomena; the percentage was high in the normal urine, fell during diuresis, and rose gradually as the quantity of urine returned to normal. The urea thus resembles the sulphates and phosphates, apparently passing through the capsules readily, but failing to penetrate the epithelium of the tubules so readily as the chloride. Cushney, therefore, explains his results in conformity with the mechanical theory of renal secretion modified by the acceptation of active absorption in the tubules. The diuretics cause a hydræmia, which induces an increased flow through the capsule, the fluid carrying with it salts in the same proportion in which they occur in the plasma. The rapid flow through the tubules permits of only imperfect absorption, but a certain amount of the water and chloride are returned to the blood, while the less diffusible bodies are excreted, it may be, in a form more concentrated than in the blood. Later more perfect absorption takes place and the urine becomes more concentrated, and the proportions are changed. Cushney concludes his argument with the statement that "the epithelium lining the renal tubules is often compared to that of a true secreting gland, such as the salivary, but it resembles that of the intestine as closely histologically and in its reaction to chlorides, phosphates, and sulphates, is analogous from a physiological point of view."

All the points raised by the adherents of the vitalistic theory seem therefore to have been satisfactorily answered. The structure of the renal epithelium can be explained quite as well on the assumption of an absorptive function as on the secretory basis. The precipitation of an indigo carmine and other dyes in the convoluted tubules may be due to a concentration of the solution by absorption, quite as well as to a secretion of the substance through the tubules. The presence of special nerve endings on the epithelial cells, as described by Berkeley and Smirnow, might seem to point to a secretory function of these cells, if it were not for the fact that they also describe similar endings on the cells of the collecting tubules. We may well therefore conclude that the weight of evidence is in favor of the Ludwig theory with the modification that not only the water of the excretion is absorbed by the cells of the tubules, but there is also an active absorption of other constituents of the glomerular fluid, the amounts absorbed varying with the diffusibility of the substances through the cells.

The question of renal sufficiency has recently been investigated by many workers and by various methods.

1. The functional activity of the kidney has been investigated by the use of aniline dyes, especially methylene blue; the important points observed are the time of the first appearance of the blue in the urine, the intensity of the excretion, and the duration and character of the process. All these factors vary in different pathologic conditions.

2. Ureteral catheterization was then used to determine in these experiments, which kidney is functionating normally or abnormally.

3. Kryoskopie, the method suggested by Korányi, depends for its value upon the physical principles (*a*) that the osmotic pressure of a fluid is proportional to its concentration (*i.e.*, to the number of molecules dissolved in a unit of volume).

(*b*) Solutions which are in proportion to their molecular weights, volume and temperature being equal, have the same osmotic pressure.

(*c*) The freezing point of solutions is lowered in proportion to the amount of solid dissolved (*i.e.*, the concentration).

Hence the lowering of the freezing point can be regarded as the measure of molecular concentration and the functional sufficiency of the kidney can be estimated by determining the difference between the lowering of the freezing point of blood serum and of urine.

The urine is a fluid of very complex composition, excreted by the kidney and representing many of the end products of tissue metabolism in the body. Its composition is shown in the following tables taken from Schäfer's "Text-book of Physiology":

I. Parkes' table showing normal twenty-four hours' excretion of main urinary constituents.

	Percentage composition of solids.	Absolute weight in grams.	Weight per 1,000 of body weight.
Urea, CH_4N_2O	45.75	33.18	0.5000
Creatinin, $C_4H_7N_3O$	1.25	.91	.0140
Uric acid, $C_5H_4N_4O_3$	.75	.55	.0084
Hippuric acid, $C_9H_9NO_3$	.55	.40	.0060
Pigment and other organic substances	13.79	10.00	.1510
Sulphuric acid, SO_3	2.77	2.01	.0305
Phosphoric acid, P_2O_5	4.36	3.16	.0480
Calcium	.35	.26	.0004
Magnesium	.28	.21	.0003
Potassium	3.45	2.50	.0420
Sodium	15.29	11.09	.1661
Chlorine	10.35	7.50	.1260
Ammonia	1.06	.77	.0130
	100.00	72.54	1.1057

II. A table derived from Bunge, representing the twenty-four hours' excretion of a young man, upon a diet consisting in one case entirely of beef with a little salt and spring water; in the second case of bread with a little butter and with some water.

	Meat diet.	Bread diet.
Amount of urine in twenty-four hours	1672 c.c.	1920 c.c.
Urea	67.2 gm.	20.6 gm.
Creatinin	2.163 "	.961 "
Uric acid	1.398 "	.253 "
Sulphuric acid (total)	4.674 "	1.265 "
Phosphoric acid	3.437 "	1.658 "
Lime	.328 "	.339 "
Magnesia	.294 "	.139 "
Potash	3.308 "	1.314 "
Soda	3.991 "	3.923 "
Chlorine	3.817 "	4.996 "

III. The differences between the excretion of certain constituents of the urine by males and females respect-

ively is indicated in the following table, given by Yvon and Berlioz:

	Male.		Female.	
	Per litre.	Per diem.	Per litre.	Per diem.
Specific gravity	......	1.0225	......	1.0215
Volume	......	1360 c.c.	......	1100 c.c.
Urea	21.5 gm.	26.5 gm.	19.0 gm.	20.5 gm.
Uric acid	.5 "	.6 "	.55 "	.57 "
Phosphoric acid	2.5 "	3.4 "	2.4 "	2.6 "

A human adult usually excretes from 1,200 to 1,700 c.c. of urine in twenty-four hours and the specific gravity varies from 1.015 to 1.025, and is in general inversely proportional to the amount excreted.

Normal urine gives an acid reaction, the acidity being due to the presence of acid salts. The question has been frequently asked and investigations have been undertaken in the effort to answer it, how it is that the urine is acid, while it is derived from the alkaline blood. Dreser and others concluded as the result of their experiments that the urine, as it passed through the glomeruli was alkaline, and that the change to the acid reaction was brought about in the cells of the convoluted tubules. Diuretics often cause alkalinity. The change in reaction may be the result either of the secretion of acid salts or the absorption of alkaline salts, by the cells of these tubules.

The degree of acidity is a resultant of two opposing factors: (1) acid production in metabolism; (2) the ingestion of unsaturated or unstable basic compounds, together with the production of ammonia. To these should be added the elimination of acids or bases by other channels than the kidney. Thus the acidity increases with increased proteid metabolism, with exercise, and with the consumption of food containing but a small amount of the bases, especially flesh food. It diminishes when the food contains abundant bases. This explains the fact that the urine of herbivorous animals is alkaline, while that of man may become alkaline, at least for a time, when a vegetarian diet is maintained (Hopkins).

Urea.—By far the greater part of the nitrogen eliminated from the body is eliminated in the form of urea, a nitrogenous substance first demonstrated by Rouelle in 1773. It is derived by the metabolism of proteid substances. The proteids form ammonium carbamate, which is changed by the liver cells into urea. This was shown by the experiments of Schroeder, Schöndorff, and others. They found that by passing the blood of a dog through the vessels of the liver, there was a marked increase of the urea present; this did not occur if the blood were passed through the vessels of the kidney or other organs. If the liver was removed, as shown by the experiments of Hahn, Pawlow, Masson, and Nencki, carbamates appeared in the urine, with a corresponding decrease in the amount of urea. Some urea is, however, found in the urine, after removal of the liver, so it is probable that some other organs have the power of forming urea, though to a much less degree than the liver. While urea is neutral to litmus, it exhibits weak basic properties and forms loose compounds with acids, so that urea nitrate, urea oxalate, and urea phosphate are met. About 30 gm. of urea are excreted in the urine in twenty-four hours. Urea itself crystallizes in the form of colorless needles or rhombic prisms, while its salts crystallize in various forms.

Creatinin is a crystalline nitrogenous substance found constantly in the urine. It is derived partly from the creatin in the meat eaten and partly from the destructive metabolism of the tissues of the body. As not nearly all the creatin taken into the body is excreted as creatinin, it is probable that a portion of the creatin is changed to urea.

Uric acid is found constantly, but in relatively small quantities in the urine of mammalia, while in birds it forms the main urinary constituent, occupying the same place with them that urea occupies in the human urine. In birds it has been shown that the uric acid is formed in the liver, as the urea is in mammalia. It has been suggested that uric acid represents an end-product in the metabolism of leucocytes and the spleen has been suggested as the place of its formation. Neumeister states: "The spleen stands in close relationship to uric-acid formation, as is evident from experiments on animals and from pathologic observations. This function is simply explained by the richness of the spleen in leucocytes and therefore also in cell nucleins, from the decomposition products of which—the nuclein bases—uric acid seems to arise, at least in mammalia." The same observations were made by Hammarsten, Horbaczewski, Spitzer, and others. Mendel and Jackson, however, working on splenectomized animals concluded that the "spleen is by no means the chief organ involved in uric-acid production in the living body, if indeed it normally plays any part whatever in this process. After the exclusion of the liver and spleen, it is natural to turn to other forms of lymphoid tissue, and the lymphatic glands are at once suggested. It might be supposed that after splenectomy these glands would take up the work of the spleen. Enlargement of the lymphatic glands has been recorded after removal of the spleen in man. But the very recent investigations of Vincent, made to ascertain this fact in the dog, fail to bring to light any permanent hypertrophy of the lymphatic glands after splenectomy. It seems improbable, therefore, that the formation of uric acid in mammalia can be assigned at present to any definite organ or group of organs. While the amount of uric acid present in the urine is small, it is of considerable importance from the pathologic point of view, since it is increased in certain pathologic conditions. The xanthin bases, which are analogous to uric acid, are found in the urine in variable but small amounts.

Hippuric acid occurs in the normal urine in small amount, the quantity varying with the diet. It is not entirely eliminated even in starvation, however, so that it arises in part also from the metabolism of the tissues. A fruit diet increases the amount, and in herbivora it is present in much larger amounts.

Albumin in traces may be present in the normal urine, arising probably from the surface of the urinary tract. This is not, however, sufficient to react to the ordinary tests for albumin. After violent exercise an appreciable quantity may appear in the urine.

Normal urine has been found to contain also not only glucose, but also a sugar of the maltose type, known as isomaltose.

Oxalic acid is found in small amounts, arising, as was recently shown by Lommel, partly from the oxalic acid in the food and partly from the carbohydrates in the food. He states that there is no direct relation between oxalic-acid excretion and proteid metabolism, and that food rich in nuclein increases both the uric acid and the oxalic acid in the urine.

The inorganic constituents of the urine are derived mainly from the food, and the amount and the form in which they are excreted are therefore very variable. A portion of the sulphuric acid occurs in the form of conjugate sulphates, the acid radical being combined with an aromatic base, so that we find indoxyl and skatoxyl sulphuric acid. About nine-tenths of the sulphuric acid occurs in the form of ordinary sulphates, the relation being changed as a result of abnormal putrefactive changes in the body and also when a larger amount of the aromatic bodies are ingested.

Phosphates and chlorides are also excreted in varying amounts and combinations. The amounts vary with the food and also with the different pathologic conditions.

In closing, I would call attention to some experiments performed by Bradford to show the result of the excision of larger or smaller portions of one or both kidneys. He states that the excision of portions of one kidney is followed by an increase of the amount of urine, without an increase of the solids of the urine. The excision of about three-fourths of the total kidney weight is followed by a very great increase in the amount of urine and also an

increase of the amount of urea excreted. The increased output of urea is, however, effected by the excretion of very large amounts of water, the urine not being concentrated. After excision of large portions of the kidney substance, there is a considerable increase in the nitrogenous extractives in the blood and tissues, especially in the muscles, the quantity being too great to be accounted for by the mere retention of the products of normal metabolism. These experiments, as well as some performed by other investigators, have suggested the possibility of an internal secretion from the kidney, the cessation of whose action causes the muscles and other tissues to break down and liberate urea. Boyd recently reported the results of the excision of large portions of the medulla of the kidney, in which he states that there was no increase in the secretion of urine or of urea, and no increased metabolism of the tissues. If the conclusions of both these observers are to be relied upon, it would seem to indicate that the increased metabolism reported by Bradford is due to some change, possibly the withdrawal of an internal secretion, brought about by the loss of the cortical substance of the kidney. *Lydia M. De Witt.*

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KIDNEYS, DISEASES OF: ANOMALIES.—Under this heading are included deviations from the normal position, size, shape, and number. Several of these anomalies may be combined; for instance, the horseshoe kidney is usually dislocated. Abnormalities are both congenital and acquired. In this article attention is paid chiefly to the congenital variety. The acquired anomaly is frequently recognized during life, the congenital very seldom, since there may be an entire absence of symptoms.

MALFORMATIONS.—Newman classifies the malformations of the kidney as follows: A. Displacements without mobility. (1) Congenital displacement; (2) congenital displacement with deformity; (3) acquired displacements. B. Malformations of the kidney. (1) Variations in number: (*a*) supernumerary kidney; (*b*) single kidney, congenital absence of one kidney, atrophy of one kidney, absence of both kidneys. (2) Variations in form and size: (*a*) general variations in form, lobulation, etc.; (*b*) hypertrophy of one kidney; (*c*) fusion of two kidneys, horseshoe kidney, sigmoid kidney, disc-shaped kidney. C. Variations in pelvis, ureters, and blood-vessels.

A. An otherwise normal kidney may be found in various abnormal positions. It may lie on the vertebral column, either on its own or on the opposite side. It is usually in the neighborhood of the promontory of the sacrum, seldom rising as high as the fourth lumbar vertebra; but on the other hand, in a few cases, it is situated deep in the pelvis in the concavity of the sacrum. According to Kupfer, these anomalies depend on a deficient energy in the movements of the embryonic rudiments of the kidneys, which up to a certain time are situated immediately in front of the point of bifurcation of the aorta. Congenitally dislocated kidneys are usually altered in form. They may be flattened, roundish, and sometimes three- or four-cornered. The hilus is directed forward. Fœtal lobulation of the surface is usually strongly marked. It occurs chiefly in men—and the left kidney is more often affected than the right. It is impossible to differentiate a congenital displacement from a floating kidney which had become fixed later in life. The practical importance of this abnormality is slight. A deep-seated kidney might be mistaken for a tumor in the pelvis. A complete rectal examination should help clear up the diagnosis.

B. ANOMALIES IN FORM AND SIZE.—Secondary alterations in the form of kidneys are of course very frequent and are produced by numerous diseases of the kidney itself, such as cyst, abscess, hydronephrosis, chronic nephritis, new growths, and by tumors of neighboring organs, etc.

As examples of congenital alterations in form may be mentioned: (1) *The Lobulated Kidney.* On the surface of this organ there are shallow grooves, which mark the boundaries of the various renculi. This is a relic of the fœtal condition, which usually disappears soon after birth, but sometimes persists. From seven to twenty renculi are found in the state of permanent lobulation.

(2) *Horseshoe Kidney.* This type represents a combination of anomalous form and position. The fusion of the two kidneys occurs at three points according to which this variety of deformity is divided into three classes. (*a*) The most common anomaly is where the fusion takes place at the lower ends of the kidneys. This represents the pure type of the horseshoe kidney (Ren Unguiformis, Renes Arcuati; Ren Soliformis). The concavity looks inward and upward.

(*b*) The second form is not so common. In it the union takes place in the middle between the two hila. There may be only a thin bridge of tissue between the two kidneys.

(*c*) The third form is the rarest. The fusion takes place at the upper end.

In the highest grade of this variety, the fusion may involve almost the entire kidney, leaving only the lower end free; at times they are separated by only a shallow depression. The fusion may be such as to give the kidney a sigmoid or a disc shape.

These anomalous forms of kidneys may prove of surgical interest from the standpoint of diagnosis and operative treatment. Landwith mentions a case in which

this condition was mistaken for a dilatation of the abdominal aorta. In another case, as a result of congestion of the fused kidney, a compression was suddenly exerted upon the underlying vessels, which caused a thrombosis of the large veins; death resulted from a complete arrest of the circulation. Previous to this time, although the isthmus lay over the abdominal aorta and inferior vena cava, it was raised with each arterial pulsation, thus lessening the pressure on the vena cava.

The anomalous form and position of the kidneys may, under certain circumstances, be responsible for interference with the escape of urine, with a fatal termination. Such a case has been reported by Koster—the pregnant uterus pressed upon the displaced ureter causing a pyelonephritis.

B. von Langenbeck has seen children die suddenly with brain symptoms, probably uræmic, in whom a horseshoe kidney was found at autopsy.

These kidneys are usually found in abnormal positions, even in the true pelvis, lying in the cavity of the sacrum. Sometimes they are on one side and may present nodular, irregular masses in which inflammation and suppuration may occur.

In any case of a single kidney the possibility of it being a fused kidney must be considered. Bachhammer gives the following means of distinguishing between them. In the single kidney with two ureters, they open either individually, or after fusion, into the same side of the bladder. A fused kidney has two ureters which open into the bladder normally.

Most cases of crossed dystopia occur in males. It does not predispose to disease. In sixty per cent. of cases the right kidney was displaced. The frequency of the anomaly is very small. Morris noted its occurrence only once in 14,318 autopsies performed at different London hospitals. It is due primarily to a fusion of the two metanephric blastemata, the dystopia being a result of this. Each ureter has its own clientèle of pyramids.

(3) *Absence of One Kidney.* We sometimes meet with cases in which one kidney is entirely absent. These must not be confounded with cases in which there is great congenital atrophy of one kidney, dependent on rudimentary development of renal vessels.

When the kidney is entirely absent, the corresponding ureter will be invariably absent. It is a rare thing for the ureter of a solitary kidney to cross over to the opposite side before it opens into the bladder. There is usually no disturbance in the renal function. The kidney is hypertrophied and thus takes upon itself the work of two kidneys. Following a nephrectomy the remaining kidney undergoes hypertrophy. If, however, it should become involved in disease, or the ureter should be obstructed by a calculus or compressed by a tumor, very alarming symptoms supervene. In twenty-four cases in which the cause of death was given, in twelve it was due to the anomaly; in ten it was due to the presence of renal calculi plugging the ureter, in two to pressure on the ureter by cancerous tumors. In operations upon the kidney the surgeon should make certain that his patient has more than one kidney. The fused kidney is most likely to deceive the surgeon; it is enlarged and displaced and may be mistaken for a new growth. In Polk's case the organ was removed under the belief that it was a floating kidney. The patient lived eleven days, had complete anuria, and it was found post mortem that the patient's only kidney had been removed.

The cystoscope has proved of great value in diagnosing the presence of two kidneys. It could not, however, exclude the fused kidney, since in this variety the two ureters might open into the bladder in a normal manner.

Ballowitz found in two hundred and five cases of absence of one kidney that in fifty-seven per cent. it was the left which was lacking.

(4) Congenital absence of both kidneys is an extremely rare condition, occurring only with extreme defect of development. It is, of course, incompatible with continued existence.

(5) In a few exceedingly rare cases of fused kidney, the supernumerary renal parenchyma is not united to the two kidneys, so that the middle piece constitutes an independent kidney, which receives blood from both lateral parts, but also possesses in part independent vessels.

C. Variations in Pelves, Ureters, and Blood-Vessels.—When only a single kidney is present there may be one or two pelves and one or two ureters. These may open separately or they may fuse and have but a single opening. It is a rare thing for the ureter of a solitary kidney to cross over to the opposite side before it opens into the bladder. In the different varieties of fused kidneys, the veins and arteries are usually abnormal, both in number and in position. Branches frequently pass to the kidneys from one or both of the common iliac arteries. The hila occur on the anterior surface in the majority of cases, consequently the ureters pass in front of the kidneys. In the different varieties of congenitally dislocated kidneys the renal and neighboring vessels have anomalous origins, their number is usually increased, and they are shorter than normal. The ureters are also shortened and run an anomalous course. As an illustration of an unusual abnormality may be mentioned the persistence of Müller's duct.

Movable Kidney.—The floating or movable kidney, both congenital and acquired, is extremely common, especially in women. In a large percentage of the cases the right kidney is dislocated. Both kidneys are dislocated a little more frequently than the left alone. In the vast majority of cases it is simply part and parcel of a much more extensive set of displacements involving most of the abdominal viscera, stomach, intestines, spleen, liver and genital organs—so-called Glenard's disease, in which the symptom complex is that of neurasthenia combined with digestive disturbances. It is highly important for the clinician to keep this in mind when considering the question of operation. Before performing nephrorrhaphy he must be absolutely certain that the symptoms come chiefly from the dislocation of the kidney. There is usually a symptom complex, due to involvement of most of the abdominal viscera. An attempt to correct *one* of many displacements *may* have absolutely no effect toward correcting the symptoms of the patient. In rare cases the kidney may alone be dislocated, or it may alone be the cause of the symptoms. In such cases operative interference may entirely relieve the patient. This condition is extremely common, occurring especially in slender, poorly nourished, emaciated women. In many cases it is congenital, these patients having always been poorly nourished and having always possessed long, lax peritoneal attachments. It was formerly thought to be due chiefly to frequent child-bearing, and the resulting lax abdominal wall, with diminished intra-abdominal pressure. We now know that it is frequently found in young women who have never borne children. Rarely it occurs as a result of trauma and heavy lifting. It frequently comes on after prolonged wasting illnesses, such as the acute fevers and dyspepsias, thus depending upon the disappearance of fat from about the kidney. Consequently there is a medical side to the question. The patient should be brought up to a normal state of nutrition if possible. The musculature, especially that of the abdominal wall, should be developed. If necessary, in the severer grades special abdominal supporters may be used, in which the pressure is exerted from below upward. The degree of movability is varied. In many apparently normal women the lower border of the kidney, especially of the right, can be felt. This is termed the *palpable kidney.* The next degree is the *movable kidney.* On deep breathing the organ is forced down between the palpating hands, but returns during expiration. The next degree is the *floating kidney.* It is extremely movable, can be pushed into different parts of the abdomen, and is very little influenced by breathing. It assumes different positions with varied positions of the patient, may even reach the true pelvis, or the opposite side of the abdomen. Such a kidney as this is nearly always associated with a marked splanchnoptosis. If the symptoms of Dietl's crisis (*i.e.*, paroxysmal attacks

of renal pain) and hydronephrosis are present, and predominate over the general symptoms of splanchnoptosis, the kidney should be stitched into place. Dietl thought these symptoms were due to strangulation of the kidneys, or to twists or kinks in the renal vessels due to the extreme mobility. The association of floating kidney with dilated stomach has been emphasized by many authors. The combination of gastroptosis and nephroptosis is very much more common, but they are both parts of the same pathological condition. It cannot be said positively that nephroptosis bears a causal relation to dilatation of the stomach. *James Rae Arneill.*

KIDNEYS, DISEASES OF: AMYLOID DISEASE.—(Synonym: Lardaceous or waxy kidney.)

History.—The names of Rokitansky, Meckel, and Virchow are intimately associated with the early history of this degeneration. In 1842 Rokitansky described the gross pathology of the lardaceous kidney, and spoke of it as a separate form of Bright's disease. Before this time it was considered a simple form of Bright's. Later, Meckel emphasized its various etiological factors. He established the iodine and sulphuric-acid reaction, but thought the substance was identical with cholesterin. Virchow pointed out the errors in Meckel's demonstration. He believed that this substance belonged to the cellulose group, because of its reactions with iodine, and gave to it the name amyloid, which has clung to it ever since, notwithstanding the fact that it was soon proved that the substance was of an albuminoid rather than a starchy nature.

Etiology.—It was early recognized that this degeneration was secondary to the various cachexias. Prolonged suppurative processes, especially of bones, are the most frequent causes of amyloid degeneration. As illustrations of other causes in this class may be mentioned: empyema, bronchiectasis, pyelitis, psoas abscess, etc. There seems to be a peculiar etiological connection between chronic ulcers of the feet and amyloid degeneration. Syphilis and chronic pulmonary tuberculosis are fairly common causes. Rarely cases have been found following carcinoma. As one would expect from its varied etiology, this degenerative process attacks many tissues. It may, however, localize itself more in one organ than in another. We then speak of amyloid disease of the liver, spleen, or *kidneys*, etc.

Morbid Anatomy.—The gross appearance of the kidneys depends upon the extent of the degeneration and the variety of the associated nephritis. In the early stage, when the vascular loops of only a portion of the Malpighian corpuscles are affected, the kidney may appear apparently normal. But as soon as the degeneration is at all extensive the kidney enlarges. The change is seen especially in the cortex, which, with its light yellow color, contrasts strongly with the red pyramids. When of long standing it has a homogeneous appearance. The enlarged Malpighian tufts appear, in the words of Meckel, like sparkling dew drops. If the pyramids become extensively involved, they are pale. The capsule strips off easily. The microscopical study is greatly facilitated by the peculiar reaction which amyloid tissue shows to iodine. A watery solution of iodine, tincture of iodine, or Lugol's solution (pure iodine 0.5 gm., potassium iodide 5 gm., and water 200 c.c.) may be used. If the degeneration is well advanced, the iodine solution may be poured over the cut section and the amyloid tissue, by virtue of the color reaction, recognized with the unaided eye. For more accurate microscopical work, fine sections from the fresh preparation, thoroughly washed with distilled water, are placed in one of the diluted solutions of iodine. The amyloid tissue strikes an iodine color (mahogany or ruby red) which appears to be due to a special affinity which this tissue has for iodine—a sort of absorbing process. The addition of sulphuric acid changes this color to a black. This was formerly supposed to be blue, and to indicate the presence of starch. We now know that the acid acts upon the reagent and not upon the tissue. The amyloid change is intertubular and almost entirely vascular. The Malpighian vessels first show the characteristic reaction, the capsule remaining unaffected to the last. The straight vessels of the cones are next attacked. The interstitial tissue apart from the blood-vessels is usually unaffected. The epithelium does not participate in this change. The iodine reaction has been noted by Dickinson in casts within the tubes.

Symptoms and Signs.—There are no pathognomonic signs of this condition. Osler states that it is simply an event in the process of chronic Bright's disease, more commonly of the parenchymatous variety. The presence of albumin in the urine, and of œdema or diarrhœa, is very suggestive, especially if combined with the presence or a history of prolonged suppuration, syphilis, or tuberculosis. These patients are usually pale, emaciated, and cachectic. This degeneration may occasionally be found in well-nourished syphilitics. They are almost always anæmic, however. The detection of an enlarged liver or spleen not otherwise explained is extremely suggestive. Diarrhœa is a frequent and important symptom, and in some instances is due to involvement of the intestine by the lardaceous process. If persistent, it has much to do with the fatal issue. Dropsy, according to some authorities, is a fairly common sign, but is frequently absent. The variety of nephritis, associated with the amyloid degeneration, must of necessity alter the signs. Dickinson states that apoplexy and albuminuric retinal changes are uncommon in amyloid disease, because of the absence of increased arterial tension and cardiac hypertrophy.

The urine shows important changes, but from these alone a diagnosis of this degeneration cannot be positively made. The quantity is usually increased, varying according to Stewart from 1,080 to 6,000 c.c. in the twenty-four hours. It is pale, clear, and of low specific gravity,—from 1.006 to 1.017. Albumin is usually present and often abundant. The sediment as a rule is scanty. Hyaline, granular, or fatty casts may be found. The amyloid reaction has been noted in the casts, but is rare. Intercurrent affections, such as pneumonia, pleurisy, pericarditis, and peritonitis, may occur, but are not so common as in the parenchymatous or interstitial forms of nephritis.

The duration of the disease is extremely variable, depending largely upon the associated nephritis. It may be very acute or prolonged indefinitely, as in certain syphilitic cases. It is difficult to tell at just what time in the course of the disease the amyloid degeneration begins.

Treatment.—An attempt should be made to remove the causative disease—suppuration, syphilis, etc.—before the development of the amyloid degeneration. If it is too late for this prophylactic measure, the treatment is that of the associated nephritis, together with attention to the causative disease, if still present. If this is syphilitic in origin the iodides should be administered. Grainger Stewart claims to have seen a case almost cured under the use of the iodide of iron. *James Rae Arneill.*

KIDNEYS, DISEASES OF: CONGESTION.—Congestion or hyperæmia of the kidneys may be acute or chronic, active or passive.

Active congestion of the kidneys is a condition of acute or active engorgement of the blood-vessels of the kidneys unassociated with exudation. In most cases it represents the earliest stage of acute nephritis; in other cases it is part and parcel of this disease; and inasmuch as it is extremely rare for acute congestion of the kidneys to exist without at least a slight amount of exudation, there can be no sharp dividing line between such acute congestion and acute nephritis. Indeed, the typical examples of "acute congestion" of the kidneys encountered after death are almost exclusively examples of acute Bright's disease. In the great majority of cases, therefore, the etiological factors of active congestion of the kidneys are the etiological factors of acute nephritis (*vide infra*). However, it is likely that in some cases congestion

may exist alone—*e.g.*, in conditions of mild toxæmia, such as occur in certain infective diseases; in mild poisonings by certain drugs and chemicals, such as cantharides, copaiba, turpentine, arsenic, carbolic acid, etc.; after the use of certain stimulating diuretics; after the administration of ether for anæsthesia, etc. It has been attributed also to sudden contraction of the blood-vessels of the periphery of the body following exposure to cold, and to loss of vaso-motor control. It probably occurs also in conditions of increased functional activity, such, for instance, as occurs in one kidney after extirpation of its fellow, and when one kidney has been rendered functionless by the blocking of its ureter with a calculus, etc. In acute congestion the kidney is enlarged, somewhat softened, and deep red in color, or reddish-brown and mottled; its capsule strips readily and reveals distended and congested vessels, and on section the organ drips blood.

In general, symptoms are wanting; at most, they are indefinite. In cases with definite symptoms there is more or less disturbance of the renal epithelium, and the condition, except in that it disappears with removal of the cause, is scarcely to be distinguished from acute toxic or degenerative nephritis, or the mildest grades of acute diffuse nephritis (*vide infra*).

Passive congestion (mechanical congestion) of the kidneys occurs most frequently in conditions of general venous stasis, and less frequently in cases of more or less obstruction to the return circulation from the renal veins, such, for instance, as may result from pressure on the renal vein or veins by a tumor, aortic aneurism, pregnant uterus, ascites, deformities of the vertebræ (causing angulation of the renal vein), and in cases of thrombosis of the ascending vena cava and renal vein or veins. In most cases it is associated with failing cardiac compensation due to valvular disease of the heart, fibroid heart, adherent pericardium, emphysema, interstitial pneumonitis, chronic adhesive pleuritis and mediastinitis, extensive tuberculosis of the lungs, etc. It occurs also in cases of cirrhosis of the liver.

The kidney the seat of passive congestion (cyanotic induration, cardiac kidney) is enlarged and much firmer than normally; the capsule strips readily and reveals distended veins, and usually a smooth surface that is dark bluish-red in color. On section the cortex is increased in thickness, dark bluish-red in color, and often distinctly striated. The pyramids usually are still darker than the cortex, being purplish. After the congestion has persisted for some time the kidney may become reduced in size, the capsule may be slightly adherent, and the surface slightly granular (the congested and contracted kidney). Microscopically, in the early stages there is marked dilatation of the veins and capillaries. The parenchyma may be normal, though usually, especially if the process has lasted for some time, the epithelium reveals more or less degeneration—parenchymatous and fatty. In the early stages the interstitial connective tissue reveals no noteworthy changes. After the process has persisted for some time, however, with gradual destruction of the parenchyma, the connective tissue becomes hyperplastic and subsequently contracts. In reality, the condition is a diffuse nephritis.

Clinically, passive congestion of the kidneys manifests itself by lessening in the amount of urine (due to diminution in the arterial pressure and consequent retardation of the circulation of the blood)—the daily amount in some cases being less than 200 c.c. In addition, the urine is dark in color, turbid, of increased specific gravity (1.028–1.035), and usually it deposits a considerable sediment of uric acid and urates. It always contains a small amount of albumin—the amount depending upon the functional activity of the heart and the degree of associated changes in the renal epithelium, but scarcely, if ever, exceeding one-tenth or one-eighth by bulk (after the heat-and-acid test). In uncomplicated cases the sediment contains only a few hyaline casts, maybe no casts. In many cases a few epithelial or granular casts, some renal epithelium, a few leucocytes, and erythrocytes may be encountered; but these are referable to some complication, such as concomitant nephritis, congestive hemorrhages, hemorrhagic infarcts, etc. In uncomplicated passive congestion of the kidneys uræmia is practically unknown.

The *diagnosis* of passive congestion of the kidneys usually is a matter of comparative ease. The symptoms of the primary disorder are always of much importance. Occurring then as part of a general venous congestion in failure of the circulation, congestion of the kidneys is readily recognized. Especial diagnostic value attaches to the association of the urinary changes with enlargement of the liver and spleen, dropsy, and cyanosis. The cyanosis and dropsy contrast strongly with the pallor and dropsy of Bright's disease. Further, the amount of urine voided daily, as well as the amount of the albuminuria, varies from day to day with the functional activity of the heart. The urine then furnishes trustworthy evidence of the condition of the venous circulation—whether it is free or more or less impeded. In some cases with marked venous congestion difficulty may be encountered in differentiating the condition from a condition primarily renal and secondarily cardiac (*vide* Chronic Interstitial Nephritis).

The *prognosis* depends wholly upon the primary disorder and upon whether the lesions of diffuse nephritis have developed. In uncomplicated cases complete restitution of the kidneys may occur.

The *treatment* is the treatment of the primary disorder. In most cases then it is the treatment of failing cardiac compensation—rest, a nutritious and readily assimilable diet, cardiac tonics and diuretics, especially digitalis, strychnine, caffeine, alkaline diuretics, sparteine, theobromine, diuretin, etc. *Aloysius O. J. Kelly.*

KIDNEYS, DISEASES OF: NEOPLASMS.—Morbid growths of the kidney occur more frequently than is generally supposed. Clinically, any enlargement of the kidney which we detect by physical examination is spoken of as a tumor; several of these enlargements have already been considered, namely, hydro- and pyonephrosis, perinephritic and nephritic abscesses, tuberculous enlargements, etc.

Other tumors are now to be considered, and for purposes of description they may be taken up in one of two ways, or in a combined way: I. As to histological structure of the swelling, or, II. As to position of the growth with reference to the kidney.

I. Varieties as to pathological structure:

(*a*) Benign.
- Adenoma.
- Lipoma.
- Fibroma.
- Angioma.
- Myoma.
- Leukæmic tumors.
- Villous papilloma.
- Accessory adrenal (struma suprarenalis of Grawitz, often malignant).
- Osteoma.
- Enchondroma.

(*b*) Malignant.
- Adenoma.
- Sarcoma.
- Carcinoma.
- Lymphadenoma.
- Accessory adrenal (Grawitz).
- Cysts.
  - Hydatid.
  - Dermoid.
  - Polycystic degeneration.
  - Simple or serous cysts.

A pure pathologico-anatomical division can be made which has as its basis the various tissues which form the foundations of the tumors:

1. Those arising from the preformed connective tissue: Fibroma and lipoma; osteoma and enchondroma; angioma and lymphangioma; sarcoma, angiosarcoma, endothelioma, and perithelioma and their mixed forms.

2. Those arising from the preformed epithelium: Adenoma, cystadenoma, carcinoma, adenocarcinoma.
3. Those arising from cells of a different kind from those in the vicinity of the tumor: Accessory adrenal (hypernephroma, rhabdomyoma).
4. Those arising from retention tumors: Polycystic degeneration, solitary cysts.
5. Those arising from parasitic cysts: Hydatids.

This division, however, is not a practical surgical one, as benign and malignant tumors are classified together; consequently we will adhere to the old useful division into benign and malignant.

II. Division with reference to the position of the growth in the kidney itself:

(a) New growths of the parenchyma.
(b) New growths of the calyces or pelvis.
(c) New growths of the renal capsule.

A. New Growths of the Parenchyma of the Kidney.—These are overwhelmingly more frequent than those arising from the pelvis or capsule of the kidney. Out of 70 cases of kidney tumors observed by Israel only 2 arose from the pelvic mucous membrane, while 68 were situated in the renal parenchyma.

Of the relative frequency of the different forms, the following statement is quoted from Morris' "Surgery": of 154 cases collected from various sources there were: Sarcomata, 63; carcinomata, 41; cystic degeneration, 21; hydatid cysts, 11; adenomata, 10; papillomata, 3; myxomata, 2; lipomata, 2; dermoid cyst, 1; total, 154.

In 1,000 autopsies at the Presbyterian Hospital, New York, there were found in the kidney: Leukæmic tumors, 1; cystic kidney, 2; adenoma of kidney, 3; cancer of kidney, 7.

Benign Tumors of the Parenchyma.—These are very rare, and form scarcely six per cent. (Morris) of kidney tumors. Aldibert, out of 51 collected cases, found only 3 benign. They are of more pathological interest than surgical because they, as a rule, reach only very moderate size and give few if any symptoms. This is particularly true of angioma, lymphangioma, osteoma, and enchondroma. Lipoma, fibroma, adenoma, and their mixed forms have occasionally reached large dimensions and become the object of surgical treatment.

Lipoma.—True lipomata are rare. They must be differentiated from lipomata which arise in the substance of, or outside, the capsule, as well as from fibro-fatty changes seen as the result of calculous inflammation, pyelitis, retention of urine, etc. Some of the so-called lipomata have been shown by Grawitz, Lubarsch, and others to be small subcapsular inclusions of aberrant adrenal tissue, or of fatty tissue mixed with muscular fibres. Malignant growths may undergo fatty transformations. Usually the tumors are of mixed forms, fibro- and myxolipomata, and are often found intermingled with smooth muscle fibres.

The true lipomata are small, rounded tumors, seldom larger than a cherry, situated usually immediately under the capsule and not in the region of the hilum where fat is normally present. They may be single or multiple; when they are numerous, although each growth may be small, the volume of the kidney may be much increased. They take their origin in most part from included, scattered portions of the fatty capsule, and from the fatty transformation of connective tissue or fibroblastic cells, the "heteroplastic lipomata" (as Virchow named them, because there is no true fatty tissue normally present in the renal parenchyma).

Fibroma.—True fibromata are very rare indeed. They are found usually as small whitish nodules near the bases of the pyramids, and, on a few occasions, a very large, simple, fibrous tumor has been met with in the kidney. Such tumors have been operated on and reported by Dickinson, Bristowe, Bruntzel, Peaslee, Wahl and Bardenheuer, and others. Most of the large tumors have undergone simple softening, resulting in extensive cystic transformation; in other instances they contain muscular tissue, or are myxofibromata. Small fibrous tumors of the size of a pea, or even smaller, are not very rare and are said by Ebstein and Virchow to be formed in connection with diffuse interstitial nephritis, many of them resembling adenomata.

Adenoma.—These are usually whitish or yellowish nodules of the size of a pea, single or multiple, situated in the cortex of the kidney; they are usually encapsulated, although not invariably, and they occur in adult age. They are more frequently found in kidneys the seat of interstitial inflammation, but some regard these little bodies as due to glandular proliferation rather than as true new growths. Larger tumors may occur, from the size of a cherry to that of an orange. They may be situated just beneath the capsule, or buried in the parenchyma; they may be divided into distinct lobules by whitish bands, and surrounded by a distinct capsule. Within these there may be hemorrhagic extravasations, or there may be simple softenings and cystic formations of large or small size. These cystic forms of adenomata are especially prone to develop papillary ingrowths within them, either sessile or pedunculated.

Delafield, Ricker, Klebs, Ziegler, Thoma, and many others emphasize the fact that adenomata may develop into malignant tumors. Sabourin has divided these tumors into two groups according as the tubules are lined by (1) cuboidal or by (2) cylindrical cells. There is also a division by Weichselbaum and Greenish into (1) papillary and (2) alveolar adenomata. Both these classifications, however, seem unnecessary, because we see side by side in many of the same tumors cuboidal and cylindrical cells, as well as the papillary and alveolar forms; so that the varieties under each of these two classifications represent no new formations but are simply various stages of the same developmental processes, and are closely related to each other. The pathogenesis of these tumors is obscure. Some are undoubtedly of accessory adrenal origin, others arise from remnants of the Wolffian body, others still from isolated elements due to an error in development, etc.

Angioma.—True angioma is very rare. In structure it is practically the same as the cavernous angiomata, or erectile tumors, of the liver and parotid. It may or may not be encapsulated and is usually of a bright red color. It varies in size from a cherry pit to a walnut.

Myxoma.—Bezold and Hollen have each described a case of pure myxoma. Myxomatous changes occur in tumors of other kinds, and myxosarcoma sometimes occurs in the kidney.

Osteoma and Chondroma.—Roberts states that a fibrous tumor growing in the kidney may ossify, while the fibrous capsule of the kidney may also undergo ossification. Undoubtedly many of the so-called bony growths are in reality calcified inflammatory products, such as we find in pyelitis and pyonephrosis and in the transformation of hydatid cysts.

Cartilaginous growths are still more rare, and it is a question whether they ever occur.

Leukæmic tumors are small, scattered, roundish patches of lymphoid or leucocyte cells, which follow the course of the capillary vessels; they stuff the capillaries and transude into the surrounding tissues and give rise to hemorrhages. There is very little structure, the stroma consisting of coagulated fibrin and the normal connective tissue, the so-called growths being little more than collections of leucocytes. These tumors at times actively grow, so as to take on a truly malignant character.

Hypernephromas, which are tumors of an entirely benign character, have already been discussed in Vol. IV. Cysts are to be considered farther on in the present article.

Malignant Tumors.—These include some forms of adenoma, carcinoma, sarcoma (and myosarcoma or rhabdomyoma), and some forms of struma suprarenalis. Cancer and sarcoma are more frequently secondary than primary in the kidney, following cancer of testis, liver, stomach, pancreas, uterus, and breast. Usually both kidneys are affected as the result of a secondary infection, while as a primary disease only one kidney is first

affected, although the second may subsequently become diseased through metastatic deposits.

In 3,926 autopsies at the Middlesex Hospital, 69 cases of malignant disease of the kidney were found. Of these 54 were secondary and 15 primary new growths, and of the latter, 13 were carcinomata and 2 adenomata (Morris). In the Zurich Clinic of Dr. Krönlein in the past twenty years there have been 118 surgically diseased kidneys of various kinds. Among these there were 15 malignant tumors, 2 cases of cystic tumors, and 1 echinococcus cyst. Out of 184 operations in Schede's clinic, there were 18 cases of malignant tumors, *i.e.*, 8 carcinomata, 5 sarcomata, 2 strumæ, 3 adenomata.

Formerly all malignant tumors of the kidneys were thought to be cancer. Extended observations have now taught us that this is erroneous.

Schede's statistics of 312 cases of malignant tumors of the kidneys, taken from the literature, give the following as to histological structure: 153 sarcomata, 112 carcinomata, 28 strumæ suprarenales, 8 perirenal sarcomata, 6 mixed tumors, 4 malignant tumors of the kidney pelves, 1 malignant degenerated teratoma.

Age.—Von Bergmann has given two periods of life which are most predisposed to develop malignant tumors, namely: 1. The earliest years of life, *i.e.*, under five years. 2. The period between forty and fifty years and thereafter.

Schede has collected out of the literature 329 nephrectomies for malignant disease. Of these 117 were found in children under fifteen years of age, and the great majority of these were in the first year of life. Out of 148 collected by Morris 39 occurred under five years of age, 2 between the ages of five and ten; 6 between ten and twenty; 14 between twenty and thirty; 20 between thirty and forty; 30 between forty and fifty; 22 between fifty and sixty; 11 between sixty and seventy; 4 between seventy and eighty.

Israel's statistics concern 68 cases—of these, 61 cases, or 89.7 per cent., occurred between the fiftieth and eightieth years, 3 occurred under ten years of age. Israel remarks that it is also of theoretical as well as of practical interest that malignant kidney tumors show a strict contrast to kidney tuberculosis with regard to the predisposing age in life, as in tuberculosis 81 per cent. of all cases occur between the ages of thirty and fifty, while in kidney tumors only 1.4 per cent. occurred in the corresponding period of life.

Brodeur states that of 18 cases of cancer, 17 occurred in adults, 1 in a child; that of 27 cases of sarcoma, 15 occurred in adults, 10 in children, and, finally, that 80 per cent. of sarcomata in children appear during the first four years of life.

Sex.—In Israel's 68 cases, 45 (66.17 per cent.) occurred in men, and 23 (or 33.83 per cent.) in women.

Guillet's statistics of 99 cases give twice as great a frequency among men as among women. According to Israel's experience, there were twice as many inoperable tumors, on the first examination, among women (11 cases or 48 per cent.) as among men (9 cases or 20 per cent.). This is explained by the fact that the two symptoms in general which lead a person with a kidney tumor to the surgeon are (1) a tumor, and (2) hæmaturia. 1. A growing tumor causes less discomfort in women, particularly those who have borne children, than in men, because the former have more relaxed abdomens, and consequently a growing tumor gives less discomfort to them than to men. 2. Then, as regards the hæmaturia, it must be remembered that blood clots pass through a woman's urinary tract more easily than through a man's, while at the same time blood in the urine is often looked on as a menstrual anomaly. A man, on the other hand, is at once frightened by the appearance of blood in the urine, and hæmaturia is apt to cause a greater degree of discomfort.

PATHOLOGY.—*Adenomata.*—It was pointed out in 1875 by Sturm that renal cancer may take the form of adenoma, consisting of a true proliferation of convoluted tubules, which ultimately may be transformed into cancer. Grawitz, Sudeck, Sabourin, and Oettinger have reported cases of adenoma of the kidney followed by secondary deposits of like nature in the lung. Pilliet, Sottas, and Albarran all agree that certain renal adenomata behave like malignant tumors, both in their local and in their distant effects, *i.e.*, metastases, and that distinction between adenoma and carcinoma is sometimes most difficult; that it is impossible, either from the microscopical or from the macroscopical characters, to establish precise limits between adenoma and epithelioma; and, further, that an adenoma is sometimes only the beginning of an epithelioma. Adenomata are spheroidal in shape, encapsuled, often of considerable size, forming a prominence on the outer surface of the kidney as large as an orange, or larger. There may be many cysts, and also hemorrhages seen on section. The capsule is often thick and fibrous, and sends processes across the tumor. The stroma is frequently very scanty.

Carcinomata.—Primary cancer of the kidney is more common on the right side than on the left. In Morris' collection of cases from English literature (1884 to 1893) it was in the proportion of 10 to 6, and, in American journals during the same period, 4 to 3. Guillet's cases showed a proportion of 7 on the right side to 3 on the left. It is more frequently met with in men than in women: as 13 to 3 in the English cases; in the American, on the other hand, as 2 to 5. Guillet's 99 cases show 64 men to 35 women. (Taken from Morris.)

Primary cancer occurs in the kidney in two forms: 1. The nodular, with or without a capsule. 2. The diffused.

According to the preponderance of cell elements over the connective tissue, or vice versa, we have all varieties of cancer, from the hard scirrhus forms to the softest medullary cancers.

The growth destroys a more or less considerable part of the organ, although there is usually left some portion of the renal parenchyma. The fibrous capsule of the kidney usually covers the surface of the tumor. On section there may be a regular outlined edge to the growth, frequently surrounded by its own capsule; or, when the growth infiltrates the tissue, this independent capsule will be absent, in which case the new growth may have no regular outline. In some cases there may be two or more encapsulated masses in the kidney. The cancer may increase the volume of the kidney without altering its shape, or the kidney may be much deformed. The fibrous capsule may rupture at one or more points. The growth may extend along the pelvis and ureter. The size of the growths varies from that of a nut to tumors larger than an adult head. They do not usually reach such large sizes as the sarcomata. There may be one or more cysts in the growths, with blood extravasations or calcareous deposits within them.

The nodular variety forms the larger number of cancerous tumors. The diffuse or infiltrating form shows its character in its disposition to replace more or less of the renal tissue, spreading itself in such a way that at the time when a tumor is demonstrable the capsule, the perirenal tissues, and the lymph glands are infected, as well as the neighboring structures, such as the peritoneum, aorta, or vena cava. For these reasons the diffuse form can seldom be the object of surgical interference, while, on the other hand, the nodular form is the one which has been the more frequent subject of operation, because it only very late infiltrates or breaks through the capsula propria, and may reach a very large size before infection of the lymph glands takes place.

Sarcomata.—Simple sarcomata furnish few peculiarities. There are spindle-celled, large and small round-celled tumors, which occur as single or multiple growths. Occasionally there is a formation of giant cells. Mixed forms, as fibro-, myxo-, and chondrosarcomata occur as elsewhere, and the malignancy varies very much according to the richness of the cells, as we find in some cases hard, relatively benign forms, while in others we meet with soft, medullary, very malignant types. There may be hemorrhagic extravasations and cystic formations. Sarcomata may infiltrate the whole kidney without chang-

ing its form. Usually, however, the sarcoma forms a tumor which develops at one point, and rapidly destroys the rest of the organ. At its outset the sarcoma appears, in certain cases, separated by a capsule from the kidney, but often there is no capsule; and where it exists the capsule often bursts at some small point, and the tumor infiltrates, through this point of rupture, the kidney tissue. The sarcomata may form enormous tumors which fill more than half the abdomen. They are lobulated and of uneven consistency, being firm in some places and soft in others. They reach especially large size in early childhood, in most cases proving fatal before the fifth year. They usually rapidly invade other tissues, both far and near. In a small proportion of the cases sarcomata in children are bilateral. Sarcomata occur at any period of life. Melanotic sarcomata are almost invariably secondary in the kidney.

The round-celled vascular variety is soft and grows rapidly. It is the most common form of renal new growth, constituting twenty-three out of forty-three tumors in children operated upon since 1890. The spindle-celled form is firm, much rarer than the round-celled, of slower growth, and of less marked malignancy. Myxosarcoma rapidly attains a large size without much pain and often without metastasis. It occurred in five cases out of forty-three sarcomata operated upon in children since 1890. Angiosarcomata represent a class of growths which have very lately received a great deal of attention because they owe their origin to the cellular elements of the blood and lymph vessels, *i.e.*, they are endotheliomata. We give the views of Manasse, to whom we are indebted for an exhaustive work on this subject, although there is not unanimity of opinion as to these growths. He divides angiosarcomata into: 1. Blood-vessel endotheliomata; 2. Lymph-vessel endotheliomata, and 3. Perivascular sarcomata. As to the histology:

1. The Blood-vessel Endotheliomata. These are not nearly so frequently seen as the lymph-vessel endotheliomata, and are rare. They proceed from the capillaries and from the small veins by fine sprouts which end blindly and are filled with blood to the very end of the vessel, which may be drawn out into a fine point, represented by an endothelial cell. The capillaries and veins are much dilated and their endothelial cells multiply very greatly, projecting into the lumina which may become obliterated. As the lumina become obliterated, there is formed a tangle of strings made up of double rows of cells which have no order in their relation to each other, and are without any connective tissue. Hyaline degenerations and necroses may take place, forming great or small cysts which may have papillary projections from their walls.

2. Lymph-vessel Endotheliomata are more frequent than the above, and are characterized by their clear-cut formation. They show a connective-tissue stroma, through which are drawn regularly branching, net-like strings of cells, which correspond to the lymph vessels filled with tumor cells. Now and then one finds typical, isolated lymph vessels which are likewise filled with grown epithelial cells, and which one can easily recognize as lymph vessels by the sinus-like dilatations, by their valves, and by their position with relation to the arteries. The lymph spaces are also commonly filled with tumor cells. The proof that these growths are not carcinomata but truly consist of proliferated endothelium can be conclusively shown only by examining the youngest forms of the new growth. Here one sees in a lymph vessel the normal endothelial coating gradually becoming transformed into the cells which we see in the remainder of the tumor. The endothelial cells become continually thicker till they finally liken themselves to epithelial cells. In carcinoma one is in the position to demonstrate, outside of the epithelial filling-up masses in the lymph vessels, the normal coating of epithelial cells still present. Such an occurrence of tumor cells and endothelial cells beside each other is impossible. In the later stage of these endotheliomata there may be an alveolar arrangement, and great and small cavities may arise, corresponding to lymph cysts. From these walls papillary outgrowths may project. The differential diagnosis from cancer may be very difficult—the net-like arrangement of cell strings, the facts that the tumor cells have no similarity to the epithelium of the uriniferous tubules and that they do not lie together in such unformed cell trabeculæ as in the carcinomata, will render it possible, in most cases, for the observer to make the right diagnosis.

3. Perivascular Sarcomata, or Peritheliomata. In these also the characteristic arrangement is the net-like disposition of the tumor cells. The trabeculæ of the net are formed of thin-walled, partly blood-containing, partly obliterated vessels, which in a very characteristic way upon their outer side are covered by a mantle of cells which at times consist of a simple double row of cells, at other times of several layers. These cells have again either the character of small endothelial-like, spindle-shaped cells, or more that of a cylindrical or club shape. Through the fact that this vascular network, with its cellular covering, is not embedded in a basement tissue but makes up the tumor mass, there is furnished to us an explanation of the decided spongy appearance which it presents. As now the adventitia cells further proliferate, the spaces below the trabeculæ of the network gradually become more or less filled up. One sees then isolated cells which may retain the character of the adventitia cells, or which may become changed to an almost epithelial-like character, giving to the tumor an alveolar, almost carcinomatous appearance. In older portions of the tumor the picture is more complicated. In place of the delicate blood-vessels with their cell mantles, which formed the trabeculæ of the network, we find broad processes, of light-colored, sometimes hyaline connective tissue, poor in nuclei, which in any case is covered on its outer side by the already described cells; while the meshes are empty, or are partly filled with cells. Occasionally we find in the midst of these connective-tissue trabeculæ double rows of endothelial-like cells, which correspond to obliterated blood-vessels. Besides hyaline degeneration in the tumor, there may occur amyloid degeneration, and rich amounts of glycogen may be made out in the tumors. The perivascular sarcomata occur sometimes pure, often partly mixed with other forms of sarcomata.

Embryonal Adenosarcoma.—While the so-called hypernephromata (struma suprarenalis), which arise from included adrenal remains and consequently rest on anomalies in congenital formation, develop first in the later years of life, at the same time there are other forms of tumors in the kidney which also take their origin from failures in development, which are characterized by a very rapid growth and marked malignancy, and which are observed at times not only in the new-born, but also in the first four years of life. They have been described partly as sarcomata, partly as carcinomata, partly as rhabdomyosarcomata, without corresponding clearly to the types of carcinomata or sarcomata. They consist of a proliferation of the elements of embryonal tissue—*i.e.*, there is an increase of the glandular elements as well as a sarcomatous proliferation proceeding from the connective tissue. The relative quantities of these two elements are very different in different tumors or parts of the same tumor, *i.e.*, sections taken from one part of a tumor may show adenoma or carcinoma, those from another part spindle-cell sarcoma, and those from still another part may be transition forms from adenomatous to sarcomatous tissues. The greater part of these tumors represents a combination of epithelial growth of adenomatous arrangement with varying degrees of development of smooth and striated muscle fibres in the stroma. Many authors consider it unwarranted to attempt a systematic division according as to whether the one or the other element preponderates. It seems better, instead of classifying the greater part of these malignant tumors of early childhood as carcinoma, adenocarcinoma, sarcomatous carcinoma, adenosarcoma, adenochondrosarcoma, and myosarcoma, to put them into one single group, and to designate them as the embryonal or sarcomatous adenoma of the kidney re-

gion in childhood. The rhabdomyosarcoma must be reckoned in this group, not only because the anomalies of embryonal formation are conspicuous, but also because the majority of these tumors contain epithelial elements in adenomatous arrangement.

They are very different in development from cancer. They occur in the earliest years of life, grow at first slowly, then later increase very rapidly to enormous tumors, and produce general symptoms by the mechanical pressure which they exert upon neighboring organs. The infrequency of the direct contiguous invasion of neighboring organs, and the relatively small disposition to metastatic deposits form a sharp contrast to cancer of the kidney of later years. These tumors fail totally to show the typical encroachment upon the healthy neighboring tissue which we see in cancer cells, but the glandular elements of these embryonal, sarcomatous adenomata show a sharp demarcation from the healthy kidney tissue, which is destroyed only by the direct pressure of the growing tumor. In these tumors there is not a complete adult formation of glandular (adenomatous) tissue, but epithelial and sarcomatous elements proliferate in a similar way, and the embryonal character of the new growth shows itself both in the immature condition of the adenomatous (glandular) tissue and in the character of the stroma with its young forms of the different elements of connective tissue (in the widest sense of this term).

The Hypernephroma (*Struma Suprarenalis Aberrans*).—As this form of renal tumor is very fully discussed in Vol. IV., we do not need to devote any space to its consideration in the present article. (See *Hypernephroma.*)

Cysts of the kidney will be spoken of farther on in the present article.

Lymphadenoma is a growth of tissue closely resembling in structure that of the lymphatic glands. This overgrowth of lymph-adenomatous tissue occasionally occurs in organs such as the kidney, liver, testis, and skin, wherein traces only of such tissue are to be found normally, as well as in the lymphatic glands themselves. It occurs in the kidney in association with the same affection in other organs. The primary seat of the disease is in many cases impossible to distinguish.

The Propagation of the Tumors.—This may happen in five different ways:

1. By direct contiguous infection of its neighborhood after perforation of the capsule.

2. By infection along the lymph channels (and glands) accompanying the blood-vessels (particularly in the case of carcinomata). The enlarged lymph glands along the renal vein may compress this and produce obstruction in the veins of the abdomen, thigh, and scrotum.

3. By the tumor directly growing into the renal vein, and even into the vena cava (observed particularly in hypernephroma and angiosarcoma).

4. By metastatic deposits in distant parts of the body, transported by way of the blood stream (in the case of sarcomata particularly).

5. By infection of the ureter and bladder through the urinary stream.

Unfortunately, in most cases there are few diagnostic points which will help us to ascertain whether there has already taken place an infiltration beyond the kidney or not, unless we except very evident cachexia and palpable changes in other organs. Neither the duration of the disease nor the size of the tumor gives us help in deciding; for hypernephromata often maintain a benign character for many years and then suddenly change to one of a malignant character. The same may be said of some sarcomata. Schede has twice removed very large malignant tumors of eight and ten years' standing, in one of which (a hypernephroma) there was no recurrence at the end of the third year, and in the other (a carcinoma) there was complete health at the end of the seventh year. Israel relates two cases of tumor of ten and eleven and one-half years' standing which at autopsy showed no metastases outside of the kidney. A symptom of great importance in helping the surgeon to decide as to the advisability or non-advisability of attempting an extirpation is the movability of the tumor, since a freely movable tumor is naturally the most favorable for operation. Extension of the disease may not, however, always lead to immobility of the kidney; nor does the extension of the disease through the capsule always lead to circumscribed nodules which can be differentiated by palpation from the kidney tumor itself; infected lymph glands are not commonly detected, nor does the thrombosis of the great veins always make itself evident by perceptible obstructive appearances in the epigastric, spermatic, or crural veins, nor are initial metastases appreciable.

Of practical diagnostic import is an inquiry into what portion of the kidney is that in which the first development of the tumor most frequently takes place, because upon this topographical relation depends their early palpability, and consequently the probable result of an operative procedure. Israel gives the following figures on this point as regards his cases: Among 38 kidney tumors, 12 times the upper half, 15 times the lower half, 11 times the middle segment was involved. Thus in about 70 per cent. of the tumors, the lower and middle zones were involved—*i.e.*, portions of the kidney which are accessible to palpation. On the other hand, 30 per cent. of the tumors developed in the upper pole—a locality in which they are not palpable unless the kidney prolapses. In addition, the topographical relations of the tumor to the kidney cross-section are of importance. Small prominences on the posterior surface, covered over by the lowest ribs and the thick back muscles, are much less easily palpable than those on the anterior surface and on the convex edge. Israel's 39 cases gave the following relations: Three cases failed to show a decided prominence on the kidney surfaces; in 17 cases the tumor showed an equal prominence in front and behind; 12 showed the tumor either exclusively or preponderatingly upon the front surface; 6 times the prominence showed itself peculiarly situated upon the convex edge; in one single case only had the growth entirely developed upon the posterior surface of the kidney. According to these figures conditions are generally favorable for palpation of the tumors.

SYMPTOMS.—The leading symptoms characteristic of a tumor of the kidney are: (1) hæmaturia; (2) pain; (3) tumor (more or less solid). Subsidiary symptoms are: (4) modifications in the character of the urine; (5) varicocele; (6) metastases; (7) general constitutional symptoms.

Hæmaturia.—This occurs as the first symptom in at least fifty per cent. of all cases of malignant tumor in the adult (Morris). Tumors which commence in the portions of the kidney away from the mucous membrane of the papillæ, calyces, or renal pelvis may cause a palpable enlargement before producing hæmaturia. Denaclara, in a collection of 409 instances of new growths of the kidney, of which 168 were patients of adult age, found that hæmaturia was the first symptom in 68.88 per cent. of the adult cases. Chevalier gives 26.6 per cent. of the cases as having hæmaturia as the first symptom. Seventy per cent. of all Israel's cases showed hæmaturia as the first symptom which was observed by either the patient or the physician. It must be considered very fortunate for the patient, from the standpoint of prognosis, when hæmaturia occurs early.

Guillet says that hæmaturia due to renal tumor (1) is often spontaneous; (2) is not influenced by repose or exertion; (3) occurs at any period of the disease; (4) is repeated at variable intervals; (5) is usually profuse; (6) lasts for from one to six days and may subside completely, to recur in a few hours; (7) is often preceded by pain. The blood is intimately mixed with the urine, but may be accompanied by clots.

Almost all malignant tumors of the kidney present hæmaturia. In 92.1 per cent. of Israel's 66 cases it was present.

The hæmaturia comes on usually spontaneously, without appreciable cause, in the majority of cases, although a trauma may undoubtedly produce it. It may be preceded and accompanied by pain, and even by colic; in other cases it is entirely unexpected, the patient suddenly finding that he is passing blood with his urine without

any premonitory or accompanying symptoms. It may occur in the night while the patient is quietly sleeping. It is often abundant, recurring at longer or shorter intervals, leaving the patient free in the intervals. It may in some cases cause extreme anæmia by its continuance.

Recently formed, long blood clots may be passed per urethram.

In Denaclara's statistics of 168 cases of adult kidney tumors, it appears that 109 of them had hæmaturia, and in all of these except two the hæmaturia was spontaneous both in its commencement and in its cessation. It was continuous in only seven cases. In children there was hemorrhage in 41.3 per cent. of the malignant tumors, and in 30.3 per cent. of the benign tumors.

The question presents itself, What is the cause of hæmaturia in tumors of the kidney? It is probably due to congestion, caused by the pressure of the tumor on the parenchyma in the early stages, and to congestion or to ulceration into the renal calyces or renal tubules in the later stages. Malignant tumors are soft and vascular, so that they readily break down, as the frequency of interstitial hemorrhages testifies.

Source of the Bleeding.—In any case of hæmaturia the first question to answer is, From what part of the urinary tract is the bleeding coming? In general, we may say that hemorrhages arising from the urethra usually precede the act of urination, while bleedings from the bladder either follow the passage of clear urine or else urine which is slightly blood-tinged at the beginning of urination becomes progressively darker toward the end of micturition. In bleedings which arise in the kidney, there is no difference in the color of the urine throughout the duration of the micturition, and, except a clot be passed, blood and urine as voided are equally mixed together. Israel, however, relates some cases which are exceptions to these rules.

The examination with the cystoscope gives the surest method of determining from what part of the urinary tract the bleeding is coming—*i.e.*, whether the blood is escaping from the bladder or from the ureter or the kidney, since urethral bleeding is easily diagnosed. In case one finds the bladder healthy, of necessity the bleeding must proceed from either the kidney or the ureter of one side. Often one may see blood flowing out from a ureteral opening into the bladder, and for this reason a period for the cystoscope examination should be chosen, if possible, when the bleeding is going on. This one positive result may, however, lead to errors if all other points are not carefully considered. For example, if there be present, in addition to the kidney tumor, a bladder tumor which is either of metastatic origin (as in three cases cited by Israel) or possibly with no relation to the kidney tumor (as in one of Israel's cases), then a cystoscopic examination, undertaken at the time when the kidney tumor was not bleeding, might lead to the overlooking of the chief complaint, if one considered the bladder tumor to be the single source of the bleeding. If possible, ureteral catheterizations should be performed and the urines from the two kidneys separately examined.

There are also subjective symptoms dependent upon the bleeding which may give us some information as to the possible origin of the bleeding. Temporary obstruction of the ureter or stretching of the kidney pelvis may be produced by the sudden pouring out of the blood, and these may cause either colic-like pains, or else a feeling of disagreeable pressure in the kidney region. Israel says that 50.7 per cent. of his cases gave subjective sensations from which the renal origin of the bleeding could be diagnosticated, while the diseased side could be ascertained in the same way in 45.6 per cent.

Examination of the Urine.—In addition to the hæmaturia appreciable by the naked eye, there are also as a rule, in the urine which macroscopically appears to be clear, blood elements, as well as other pathological products, that may be seen by the aid of the microscope. Eighty per cent. of all Israel's cases showed this. There are red and white cells, sometimes single large fatty-degenerated cells, which may be tumor cells, generally a trace of albumin, and a few casts, as well as peculiar epithelial cells. Very rarely there may be passed pieces of tissue which may be recognized as coming from a tumor. Most of the urinary contents, however, are those which occur in several kidney affections, *e.g.*, stone, tuberculosis, chronic or hemorrhagic nephritis, etc.

Kidney bleedings awaken a strong suspicion that their cause is a tumor if they occur suddenly, without recognizable cause, in full strength, and at the next micturition have disappeared, or if, after long-continued duration, they suddenly cease, or if they are so profuse that they lead to coagulation in the ureter or the bladder. If the urine passed at each separate micturition be caught in separate glasses and placed beside each other, according to the order of their passage, and then compared, we may with very great probability make a diagnosis of kidney tumor if we find, without any regularity in their relation to each other, a dark red glass immediately next to one that is entirely normal in appearance, and next to the latter a third glass containing clear urine, with bloody, worm-like clots at the bottom.

Tumor.—The demonstration of the presence of a tumor by means of palpation constitutes the most important point in the diagnosis of a new growth of the kidney. In very many cases, however, the very early recognition, unfortunately, is not possible, either by the patient or by his doctor. It will depend in many cases, as we have already mentioned, in what part of the kidney the tumor develops. For example, tumors on the back surface of the kidney and in its upper half will be undiscoverable for a long time by palpation on account of their being covered up by the deep back muscles and by the ribs. An enlarged liver may also render palpation difficult.

Method of Palpation.—Bimanual palpation, with the patient lying on his back and with thighs flexed, may be used. Should this not be satisfactory, Israel's half-side position is more apt to give definite information. In this the patient lies on the healthy side half-way between full-side position and back position. In this posture the lower pole sinks somewhat downward, and the intestines also fall over toward the healthy side, which relaxes the abdominal walls and permits a deeper pushing in of the finger tips between the ribs and the front surface of the kidneys. This position, according to Israel, allows smaller tumors to be felt than is possible in any other position. The same author also recommends the following method: The examiner at the moment when inspiration changes to expiration, during the relaxation of the abdominal walls, gently presses the tips of the middle and index fingers of the hand lying on the front of the abdomen in under the edge of the ribs, while the hand behind exerts at the same time forward pressure upon the lumbar region, immediately under the edge of the last rib. With each successive expiration one should press in a little deeper, which prevents the kidney, which has descended with the inspiration, from receding back during the expiration, and thus the kidney becomes more accessible to palpation. Out of Israel's 68 cases, there were 62 in which the existence of a tumor of the kidney was demonstrated by means of palpation.

The chief points about tumors of the kidney in general are: The large intestine is in front of the tumor; the ascending colon is in front of and toward the inner side of the tumor, while on the left side the descending colon is in front of and inclines toward the outer side of the kidney below. Sometimes coils of small intestine may overlie a tumor of either the right or the left kidney. The bowel is never thus placed in front of a splenic tumor, and very rarely in front of one of the liver. Renal tumors do not project backward to any marked extent; they expand in front. Abscess and other lesions which may simulate renal tumors often cause considerable posterior projection. In tumors of the kidney the natural contour is usually retained throughout the larger part of this organ; *i.e.*, it generally presents no sharp edges. This absence of any sharp edges marks off renal from many hepatic and splenic enlargements. Of course, there are often sharp knobs and projections on the kidney sur-

face, but the whole kidney does not lose its rounded outline.

The most frequent and most characteristic result of palpation is to find, on the surface of the kidney, prominences which are irregularly spherical, hard, non-fluctuating, of unequal size. Much less frequently there is a uniform enlargement of the kidney with smooth surface. In 62 of Israel's cases, which had tumors of the parenchyma, 41 had inequalities of the surface, while only 5 had an even surface, there being 16 cases of which the records furnished no evidence as to the character of the surface as elicited by palpation.

Pain.—Morris gives pain as the first symptom in thirty-five per cent. of the adult cases. We have seen that typical attacks of colic and pressure sensations in the loin may be present, due to hemorrhage. In addition there may be symptoms, independent of the hæmaturia, which occur in periods free from hemorrhage, and which may give us a clew to the affected side. Thus, for example, the patient may complain of pain in one or the other side, and no apparent external cause for the pain may be discoverable. Then again, the abdominal bands of the clothing may become tight and cause uncomfortable sensations. The same may be produced by the drinking of beer, or by excessive bodily exertion. Israel says that sixty per cent. of the patients give some indications, by these abnormal sensations, as to the side affected. These sensations may be continuous or intermittent. In more infrequent cases there may be colicky attacks. These are probably due to sudden increase in the pressure in the kidney, which is surrounded by a hard, unyielding capsule. This increase in pressure is due to acute congestion in vascular tumors, or to hemorrhages within such tumor masses, which are not in communication with the kidney pelvis. Only about fifteen per cent. of the cases have this symptom of colicky attacks, so that it is not at all characteristic.

Varicocele.—As a symptom this is a rare occurrence. Guyon first drew attention to it. It has been explained by pressure of the tumor upon the spermatic vein of the affected side. It may also be due to secondarily enlarged lymphatic glands.

The *general symptoms* such as loss of flesh, anæmia, and cachexia may occur in cancer of the kidney as elsewhere. But these symptoms may not develop for a long time. Pressure of the tumor may cause digestive disturbances, constipation, jaundice, etc. In rare cases cachexia has been the first symptom noted.

Metastases.—The entire body should be carefully examined for their presence. Metastases in bony structures are particularly frequent, and careful consideration should be given to so-called rheumatic pains and to complaints of weak feelings in the legs. In rare cases this latter symptom may be the first thing to bring the patient to the physician. Israel had two such cases.

Differential Diagnosis (taken largely from Morris).—
1. The hæmaturia of renal calculus is brought on by exercise or movement, and diminishes or ceases with rest, usually in the course of a few hours, to recur under the influence of some very slight movement. There are more pain and tenderness in renal calculus than in a renal new growth, and the hæmaturia, in the former condition, usually follows an attack of colic.

2. It may be impossible to diagnose the hæmaturia of tuberculous kidney unless we find the tubercle bacilli in the urine or some other evidence of tubercles elsewhere. In renal tuberculosis, there is usually pyuria, and in the interval between the attacks of hæmaturia the urine is turbid. There may be a slight febrile rise each day. If with hæmaturia, without pyuria, there is a renal tumor, tubercle is improbable, and cancer most likely exists.

3. The hæmaturia of chronic nephritis—abundant, one-sided renal hæmaturia—may continue for days or weeks in subacute and chronic nephritis. In this latter, however, there is usually more albumin than the blood itself would explain, and there are also very numerous casts. The diagnosis is made by the fact that when the hæmaturia is absent, albumin and casts are present just the same.

4. Essential hæmaturia (angioneurotic), nephralgic hæmaturia, hæmophilia, the hemorrhage from a movable kidney (twist of the pedicle), all these must be considered in making a diagnosis.

5. From polycystic disease of the kidneys. In this disease hæmaturia is rare. In polycystic disease it is not unusual to find that both kidneys are involved, while a unilateral swelling is the rule in the case of a renal tumor. In polycystic disease the amount of urea lessens and is associated with a great increase in the amount of water, or, in some cases, with suppression of the secretion in part or entirely.

6. A large simple serous cyst of the kidney is very rare, but when it occurs the diagnosis is very difficult indeed.

7. From hydatid cysts—see article on *Kidneys, Diseases of: Parasites.*

8. From hydronephrosis, caused by a tumor of the bladder—villous papilloma or carcinoma. This may be accompanied by spontaneous, profuse, irregularly intermittent hæmaturia, having all the characters of renal tumor. Bimanual examination under ether may detect the tumor in the bladder walls, and the cystoscope should also be used.

9. As to the variety of the new growth: In the adult it is almost impossible to diagnose with any degree of certainty the nature of the tumor. Sarcomata cause hæmaturia less frequently, secondary growths more slowly. It is likewise often quite impossible to diagnose malignant from benign renal tumors, except by an exploratory incision. Even expert microscopists differ oftentimes about the nature of the same tumor.

10. Tumors of the abdominal walls are rare. Their mobility during respiration is that of the abdominal walls. They are more superficial than renal tumors and may be adherent to the skin.

11. Enlargements of the liver. Hepatic tumors rarely have intestine in front of them, as do renal tumors. There is an absence of ballottement (*i.e.*, the rocking back and forth of the tumor when grasped by both hands). Renal tumors often allow the fingers to be depressed between the edge of the costal cartilages and the upper border of the tumor. These tumors develop comparatively early an area of dulness in the lumbar region, whereas tumors of the liver and spleen do so only very late, if at all. A tongue-shaped, semi-floating lobe of the liver, or a tumor developed in the concave part of the liver is very likely to cause error in diagnosis; especially so are hydatids in the left lobe of the liver.

12. From enlargements of the spleen. The enlarged spleen has no bowel in front of it; it generally presents a sharp or well-defined edge, beneath which the fingers can be depressed, and which is often notched. There is resonance between the posterior edge of an enlarged spleen and the spinal column, and the tumor can be traced up under the ribs. A splenic tumor is movable; a renal tumor may be so, but in many cases it is fixed in the loin. A splenic tumor will not cause a varicocele, a renal tumor may.

13. Tumors of the suprarenal capsule. These are not usually of sufficient size to form an abdominal tumor; but, when they do so, it is not easy, if indeed it be possible, to distinguish them from renal tumors, nor is it of any special importance to make the distinction, since new growths of the adrenal, when of clinical importance from their dimensions, involve the kidney, and sometimes efface it.

14. Ovarian tumors. Both solid and cystic tumors of the kidney may be mistaken for ovarian tumors. In an ovarian tumor the intestines lie behind, and both loins are resonant. The tumor grows from below upward and either drags up the uterus, or can be felt as a swelling in the pelvis by vaginal or rectal examination. In the case of an ovarian tumor the subjective sensations, in the beginning at least, are referred to the pelvis.

15. Enlargements of the lymphatic glands in the near neighborhood of the kidney, when they give rise to a

swelling, have relations to the colon very similar to those of a renal tumor. The independent enlargement of one or more lumbar glands not forming part of the tumor, as well as the abruptness of the outline of the swelling, may help us in making a diagnosis.

16. From fæcal accumulations in the cæcum, sigmoid flexure, or colon, renal tumors may be diagnosed by the absence of intestinal disturbances, in the latter condition, and by the general abdominal pains and colic, and by the enlargement due to flatus, which characterize over-distention of the bowel.

17. Fæcal abscess, appendicitis, will be distinguished by the marked febrile disturbance, the tenderness, and the lower position of the swelling, which is in the iliac rather than the renal region of the abdomen.

18. Malignant growths of the large intestine. Morris remarks the close resemblance between a malignant growth of the ascending or descending colon and a renal tumor. He has seen the two diagnoses confused in six cases. Cancer of the large gut rarely has the form of the kidney. It should be suspected if, as is very likely to be the case, it is associated with diarrhœa, or possibly with loose, blood-stained movements, or with other intestinal symptoms. The peristaltic action of the intestines may sometimes be marked. More or less obstruction may be present. But this also may be caused by the pressure of a renal tumor. An exploratory incision may be necessary to determine the situation of the growth.

19. Tumors of the mesentery are more median, nearer the navel, and the anterior parietes, and are more movable, especially in a lateral direction. They have a zone of resonance all around them, due to their relation to the small intestine.

20. Tumors of the pancreas, whether cystic or cancerous, are more median in position, while their chief mobility is vertical. They may cause obstruction of the pancreatic and bile ducts; they fluctuate and often show a variation in their size from day to day. The colon, in pancreatic cyst, is not in front of the tumor, nor does the cyst project down so far into the lower part of the abdomen as do renal tumors.

Prognosis.—When once the disease has set in, the growth advances steadily. The usual causes of death are exhaustion, hemorrhage, or uræmia. Rarer causes are ulceration into the peritoneum, or into the lung with secondary pulmonary abscess, or secondary new growths develop in the brain, vertebral column, spinal cord, stomach, or intestine. The duration of the tumor, between the discovery of the first symptom and the date of death, when no operation has been performed, is from three to four years for carcinoma, and from five to six years for sarcoma (Morris).

Treatment.—Since death is the inevitable result of every malignant renal growth when left to itself, it seems justifiable to adopt very radical measures for the relief of the condition, especially in view of the fact that a fair minority may be cured, and notwithstanding the fact that death may be hastened by operation in some cases. The results of operation will be quoted later.

In general, we may say that nephrectomy is the proper treatment for renal growths. Only in a certain few cases of benign growths is a resection of the tumor alone allowable.

It goes without saying that all those cases are to be excluded from operation in which the growth has exceeded the territory of the kidney itself, *i.e.*, has extended into the fatty capsule, or in which the growth has advanced into the vena cava, or has infected the lymph glands. The difficulty, however, is to recognize these conditions before operation. In many cases it is impossible to do so and the hopelessness of the situation is only ascertained on the operating table. As the consideration of all these questions, as well as the discussion of the proper method of operating and of the results which may be expected from operative treatment, is doubtless provided for by the writer on the surgery of the kidney, the reader is referred to the article entitled *Kidneys, Surgical Affections of the*, for further information on the subject.

Cysts of the Kidney.—For cysts due to parasites, see under heading *Kidneys, Diseases of: Parasites.*

(*a*) Simple or serous cysts are not very frequent, Brackel having collected twenty-one cases out of the whole literature, from the year 1865 to 1899. They are observed only in adults between the ages of eighteen and sixty-five. They are usually solitary and may grow to large size. They cause no symptoms except those due to pressure. They arise in the cortex and project from its surface, the remainder of the kidney being healthy and functionating actively. Their contents are various: thin, clear, bloody, or colloid. Women seem to be more often affected than men, in the proportion of about fourteen women to six men. Their exact mode of origin is uncertain. The diagnosis is very difficult, as they may be mistaken for a number of other kidney conditions. Treatment consists in tapping them when they become so large as to cause discomfort. If they refill they may be laid open and the edges of the cyst stitched to those of the wound. This course, however, involves a greater loss of time before healing is completed than if the plan is adopted of totally removing the cyst and its wall, the cavity of which may then be immediately obliterated by sutures.

(*b*) General cystic degeneration of the adult kidney. In this condition the whole kidney is converted into a vast number of conglomerate cysts of varying size. There is scarcely any portion of the glandular structure which is left unchanged, and the bulk of the organ is very much increased, while retaining its renal shape. The cysts do not communicate with each other nor with the pelvis or calyces. They probably owe their origin to expansions of parts of the uriniferous tubules and atrophy of the interstitial tissue. Small portions of the renal tissue between the cysts may remain unchanged. An important fact seems to be that the disease is often an hereditary one. It does not usually develop before the fortieth year. There are instances, however, in which the disease has been observed in children. In these cases both kidneys have usually been affected. Cystic liver has often been observed as a complication, so that this seems almost like an integral part of the disease.

Symptoms.—The clinical history is much like that of Bright's disease. Israel divides the cases into four groups, as regards symptoms:

1. A not inconsiderable number of cases have uræmia as the first symptom to call attention to the kidneys.
2. Another class has symptoms referable to the urinary apparatus, such as polyuria, sometimes hæmaturia, perhaps slight vesical tenesmus, thirst and dryness of the mouth, in a few cases œdema.
3. Others have pronounced circulatory disturbances, such as palpitation, cardiac dyspnœa, due to hypertrophy and dilatation of the left ventricle, or dizzy attacks due to arteriosclerosis.
4. A fourth class complains of enlargement of the abdomen with pressure symptoms, anorexia, vomiting, abdominal pains, etc.

The character of the urine may also help in making the diagnosis, as it is like that which is observed in the cases of granular or contracted kidney. It is pale, abundant, of low specific gravity, albuminous, occasionally containing blood cells and coagula, often granular casts.

By palpation in well-marked cases we find that there are enlargements of both kidneys, and that on their surfaces are different-sized prominences, which are always regularly spherical, scarcely elastic, seldom fluctuating. The tumors are movable and have respiratory movements.

Treatment is based upon the same principles as those which govern the treatment of acute nephritis.

Paranephritic cysts do not have their origin in the kidneys but encroach on the kidneys from without. Such cases should be treated by excision.

B. Primary New Growths of the Kidney Pelvis.—These are not frequently observed. Only two out of Israel's 70 cases of kidney tumor arose from the kidney pelvis. J. Albarran has lately published the most that is

known about them. These new growths are either of epithelial character, or else they originate in the connective tissue. The epithelial new growths are either papillomata or epithelial carcinomata. Albarran found eighteen of the former and thirteen of the latter. The papillomata develop mostly at the base of the pelvis and project toward the ureter. They are similar to those which develop in the bladder, and are usually mutiple. The epithelial cancers naturally tend to infiltrate the kidney itself. From obstruction of the ureter we may get hydro-, pyo-, or hæmatonephrosis. The non-epithelial new growths develop either toward the outer surface of the kidney pelvis, or else they grow into its cavity or into the ureter. Albarran found among 7 cases, 4 rhabdomyoma, 1 myxoma, 1 angiosarcoma, and 1 endothelioma. The symptoms of these new growths are not only those of hæmaturia, pain, and tumor formation, but in addition a prominent symptom is that of retention of either blood or urine in the renal pelvis. Tumor cells may be discovered in the urine obtained from the ureter of the affected side by ureteral catheterization; or, by the cystoscope, tumor villi may possibly be seen projecting out of the ureteral opening into the bladder. Simple pedunculated papillomata should be excised, while malignant tumors require a nephrectomy with removal of the greater part of that ureter.

C. Tumors of the Kidney Capsule.—Paranephritic tumors are divided into three groups: 1. Tumors of the connective-tissue type; 2. Tumors of the adrenal; 3. Paranephritic cysts.

1. Tumors of the connective-tissue type are very various, and we may find lipoma, fibroma, myxoma, sarcoma, etc. A separate description of these is hardly necessary. As to their symptoms we may say that they grow insidiously and without pain, and the first thing noticed is an abdominal swelling. The non-malignant tumors are often very movable. The sarcomata tend to contract very firm adhesions. Only after they attain very large size do we get pain, due to pressure upon the lumbo-sacral nerves. Changes in the urine do not occur till pressure takes place, and hæmaturia is very rare. In fifteen per cent. a history of gastro-intestinal disturbances has been noted; these disturbances are due to pressure. Puncture of the growth furnishes negative results. Emaciation is extreme when the tumor reaches a large size. Extirpation constitutes the only available treatment.

2. Tumors of the adrenal. These are very hard to distinguish from those of the kidney, not only pathologically but clinically. The primary new growths of the adrenal, large enough to cause an abdominal tumor, are rare. They consist of three varieties: (*a*) A purely glandular proliferation. (*b*) Large adenoma. (*c*) Malignant growths, cancer, sarcoma.

Symptoms.—The most frequent is marked loss of flesh and strength; then next in order come gastro-intestinal disturbances and pain in various parts of the body (Mayo Robson says particularly in "shoulder tip"). The circulatory system and skin are not usually involved as in Addison's disease. Hæmaturia is not present, nor are any urinary symptoms, till the kidney itself becomes involved. The growths increase rapidly and produce metastases early.

Treatment consists in extirpation, provided exploration shows that an extension of the disease has not taken place.

3. Paranephritic cysts. The recorded cases are very few, but have been classified as follows: (1) Serous cysts; (2) blood cysts; (3) hydatid cysts.

Clarence Arthur McWilliams.

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KIDNEYS, DISEASES OF: NEPHRITIS.—(Synonym: *Bright's Disease.*)—Although Aëtius (died 367 A.D.), Avicenna (980–1036), and Van Helmont (1577–1644) attributed certain cases of dropsy to disease of the kidneys, and although Cotunnius (1736–1822), in 1770, discovered that the urine of dropsical patients is coagulable by heating, our first insight into the true nature of the non-suppurative diseases of the kidneys dates from the memorable publications by Richard Bright (1789–1858), in 1827 and subsequently. It is true that Wells (1757–1817), in 1806, Blackall (1771–1860), in 1813, and Alison (1790–1859), in 1820, anticipated somewhat the observations of Bright, but the reports of these writers were fragmentary and their reasoning was in large part erroneous. Bright, however, demonstrated the dependence of dropsy and albuminuria upon disease of the kidneys; he recognized the relationship of the symptoms to the disease, and he described accurately the lesions in the kidneys. Indeed, such were the profoundness of his knowledge and the accuracy of his observations that many of his statements have withstood the searching inquiries of more recent times. Bright recognized that although albuminuria and dropsy are the characteristic symptoms of certain diseases of the kidneys, in some cases the amount of albumin may be small and the dropsy slight or altogether absent; he described many of the associated phenomena, such as uræmia and the cardio-vascular changes, and many of the complications, such as blindness, apoplexy, inflammation of the serous membranes, etc. Thus it excites little wonder that the acute and chronic non-suppurative diseases of the kidneys, usually but not always associated with albuminuria and dropsy, and frequently attended by characteristic lesions in certain other organs, notably the cardio-vascular apparatus, have come to be known as Bright's disease.

The original observations of Bright soon received abundant confirmation in different parts of the world, and diseases of the kidney became the subject of much study and discussion. The most noteworthy of the early contributions to the subject are those by Christison (1829), Gregory (1831), Osborne (1834), Rayer (1839), and Rokitansky, the last-named writer describing the amyloid kidney in 1842. The earliest investigations of the minute anatomy of the changes in the kidneys in nephritis were made by Henle (1847), and subsequently by Reinhardt (1859), Frerichs (1851), Johnson (1852), Virchow (1852), Vogel (1852), Wilks (1852), Traube (1856), Dickinson (1860), Rosenstein (1860), and Grainger Stewart (1868),—Johnson, in particular, directing attention to the changes in the blood-vessels. In 1872, Gull and Sutton, studying anew the changes in the blood-vessels, described their now well-known arterio-capillary fibrosis and emphasized the importance of alterations in the blood-vessels in the production of cirrhosis and atrophy of the kidneys. Later, Kelsh (1874), Bartels (1876), Bamberger (1879), Mahomed (1879), Aufrecht (1879), Weigert (1879), and others contributed important articles on the subject. The literature is now voluminous. Among the most important contributions during the last two decenniums are those by Wagner, Rosenstein, Stewart, Saundby, Ziegler, von Kahlden, Dickinson, Delafield, Tyson, Councilman, Senator, Tirard, and many others.

Now, although most writers are agreed as to what constitutes Bright's disease, there is no unanimity of opinion as regards the classification of the different forms of Bright's disease—the basis of different classifications being etiological, anatomical, or clinical factors, or a combination of two or all three of these factors. The following classification is believed to be comprehensive, to accord with the anatomical findings and with the clinical course of the disease, and, in so far as is possible and desirable at the present time, it takes cognizance of etiological factors:

I. Acute nephritis.
   (*a*) Acute toxic or degenerative nephritis. (Cloudy swelling or parenchymatous degeneration of the kidney.)
   (*b*) Acute diffuse nephritis. (Acute parenchyma-

tous, exudative, catarrhal, desquamative, glomerular, tubular, or hemorrhagic nephritis.)
- (*c*) Acute interstitial non-suppurative nephritis.
- (*d*) The kidney of pregnancy.

II. Chronic nephritis.
- (*a*) Chronic diffuse non-indurative nephritis. (Subacute and chronic parenchymatous, exudative, catarrhal, desquamative, glomerular, tubular, or hemorrhagic nephritis; the large white kidney; the large red, mottled, or variegated kidney.)
- (*b*) Chronic diffuse indurative nephritis. (Sclerosis of the kidney.)
  1. Secondary chronic indurative (or interstitial) nephritis. (Late stage of chronic parenchymatous nephritis; the small white kidney; the white granular kidney; the secondarily contracted kidney.)
  2. Primary chronic indurative (or interstitial) nephritis. (The red granular kidney, the gouty kidney, the primarily contracted kidney, the genuine contracted kidney.)
  3. Arterio-sclerotic nephritis. (The senile kidney.)

I. Acute Nephritis.

Etiology and Pathogenesis.—Acute nephritis may occur at any age, though it is more common before than after the age of forty years. Aside from the kidney of pregnancy, males are more frequently affected than are females. Exposure to the inclemencies of the weather is still looked upon, by some clinicians, as an important etiological factor. The clinical association cannot be denied, though its importance has been much overestimated and its mode of operation is still unknown. With more or less reason, it has been said to act by favoring the retention of certain excrementitious products, by causing a reflex congestion of the kidneys, by giving rise to certain alterations in the albuminous constituents of the blood in consequence of which they become non-assimilable and irritating, and by producing hæmolysis analogous to that which occurs in some cases of paroxysmal hæmoglobinuria. Aside from (and possibly including) such exposure to the inclemencies of the weather, acute nephritis is due to autogenous or exogenous intoxication or infection of the kidneys—the different forms of acute nephritis being the result of differences in the amount, nature (virulence), and duration of action of the toxic or infective agent on the one hand, and of the reaction of the kidneys on the other hand. The most important of these etiological factors are the febrile infective diseases—all of which are capable of giving rise to the different forms of acute nephritis. Doubtless almost all cases of infective disease are attended by more or less decided alterations in the kidneys—alterations the consequence of the elimination of toxins by the kidneys, but alterations in some cases so slight as to give rise to no clinical manifestations. The mildest cases that are recognizable clinically are cases known usually as cases of *febrile albuminuria.*

Infective diseases, such as varicella, measles, rubella, and epidemic parotitis, may provoke acute nephritis, but it is more common and more severe in the infective anginas, influenza, typhoid fever, typhus fever, diphtheria, pneumonia, erysipelas, septicæmia, acute or infective endocarditis, smallpox, rheumatic fever, relapsing fever, cerebro-spinal meningitis, plague, dysentery, acute infective jaundice (Weil's disease), tuberculosis; in certain erythematous and purpuric affections; in impetigo, pustular eczema, etc. It is especially common in scarlet fever, yellow fever, and cholera, and it may occur in vaccinia, malaria, syphilis, etc. In most of these diseases the kidney lesions are the result of the action of a toxin elaborated by the provoking bacteria and eliminated by the kidneys. In some cases, however, cases in which bacteræmia occurs, the kidney lesions are the result also of the direct action of bacteria which, circulating in the blood, are brought into direct contact with, and are eliminated by, the kidneys—in some cases in exceedingly large numbers, as, for instance, in from twenty-five to fifty per cent. of all cases of typhoid fever. In cases in which the pyogenic bacteria are the offending agents suppurative lesions (which will be discussed elsewhere) may be produced. In addition to these bacterial poisons, acute nephritis may be caused by certain metabolic poisons, such as leucomaïns; by certain more or less imperfectly understood toxic products of perverted metabolism, such, for instance, as are associated with gout, diabetes, jaundice, hæmoglobinæmia, extensive burns, etc.; by certain chemical substances (non-biological poisons), such as spices, ether, chloroform, alcohol, turpentine, corrosive sublimate, arsenic, phosphorus, cantharides, sulphuric acid, nitric acid, hydrochloric acid, oxalic acid, carbolic acid, salicylic acid, petroleum, potassium chlorate, the chromates, etc., many of which act by inducing hæmolysis; by anæmia—primary and secondary and that following hemorrhage; and by pregnancy. In general, the toxic agents and anæmia give rise to degenerative lesions, whereas the infective agents give rise to both degenerative and inflammatory lesions. In addition, some of the toxins appear to possess a selective action in that one will implicate especially the epithelium of the glomeruli, another the epithelium of the tubules, whereas in other cases the connective tissue appears to be especially the object of attack.

Pathological Anatomy.—The kidney in acute nephritis exhibits all gradations from the mildest degenerative lesions to intense widespread inflammatory and degenerative lesions; from the slight lesions of short duration to the severe lesions that permanently damage the organ. In consequence the kidney presents quite different aspects in different cases. In the mild cases, cases presenting the slightest degenerative lesions—*acute toxic or degenerative nephritis*, the kidney may be scarcely increased in size, and it may present no noteworthy deviations from the normal. In the more severe cases, cases of moderate severity, the kidney is somewhat enlarged, more or less congested, and the cortex slightly swollen, pale grayish-red in color, and opaque. In the extremely severe cases—*acute diffuse nephritis*—the kidney may be twice its natural size, weighing 250 gm. or more. The capsule usually is tense and thinned; it strips readily and leaves a smooth surface that varies much in color. In the severe and very acute cases it is dark reddish-brown in color (hyperæmic or hemorrhagic kidney); in the less severe forms and in the later stages of the severer forms it is pale grayish or grayish-red in color (anæmic kidney); in other cases it presents a combination of these (mottled or variegated kidney). In addition to markedly congested stellate veins, the surface of the kidney usually presents certain dark red spots or streaks referable to foci of hemorrhage. On section, the kidney, if enlarged, is softer than normally, somewhat opaque (as though cooked), œdematous, and friable; if the lesions be very acute the organ drips blood. The cortex is swollen and increased in thickness, the normal striations are obscured, and the color corresponds with the color of the surface. The glomeruli may or may not be distinct. In some cases, especially in scarlatinal nephritis, they are very distinct (*glomerulo-nephritis*), appearing as minute pale grayish or dark reddish (hemorrhagic) points. Contrasting with the frequently pale cortex the pyramids are usually congested. In some cases, however, the pyramids are pale, only the boundary zone being congested.

Pathological Histology.—Microscopically the lesions in acute nephritis usually affect all the structures of the kidney—*acute diffuse nephritis.* In some cases, however, the lesions are wholly or almost wholly confined to the parenchyma—*acute toxic or degenerative nephritis,* which fact suggests that the first changes in the kidney in nephritis are in the epithelium. In other cases the lesions are especially conspicuous in the interstitial tissue—*acute interstitial non-suppurative nephritis.*

(*a*) Acute Toxic or Degenerative Nephritis.—In this form of nephritis, aside from slight changes in the blood-vessels and the interstitial tissue present in some

cases, the lesions are confined to the renal epithelium (that of the tubules as well as that of the Malpighian bodies), and they consist of: cloudy swelling (swelling and granulation of the cellular protoplasm), which is common in

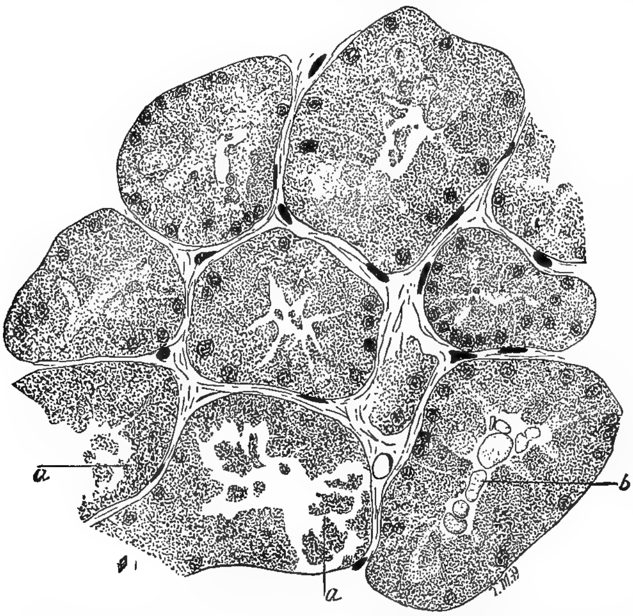

Fig. 3061.—Acute Parenchymatous Degeneration of the Kidney Epithelium from a Case of Yellow Fever. *a*, Swollen and granular epithelium desquamating and disintegrating; *b*, hyaline material in the lumen of the tubule. (Delafield and Prudden.)

most of the acute infective diseases (Fig. 3061); fatty degeneration (fat droplets in the cellular protoplasm and alterations in the nuclei), which is common in the severer infections, in certain intoxications, such as phosphorus poisoning and the like, and in severe anæmias (Fig. 3062); hydropsical degeneration (swelling of the cellular protoplasm and vacuole formation), and complete necrosis, which occur in the severest infections such as cholera, and in certain intoxications, such as, cantharidal poisoning, corrosive-sublimate poisoning, etc. These lesions are but different grades of the one process, and they may be found singly or in combination.

(*b*) Acute Diffuse Nephritis.—In this form the lesions, though widespread, are frequently exaggerated in foci, and they involve especially the parenchyma—whence the common term, *parenchymatous nephritis*. In some cases the lesions are especially conspicuous in the glomeruli—*glomerular nephritis;* in other cases, in the tubules—*tubular nephritis*. The changes in the tubules are chiefly degenerative—the cloudy swelling, fatty degeneration, dropsical degeneration, and necrosis (karyolysis and karyorrhexis) already mentioned. These are usually of a high grade, though one or the other may predominate in different cases, and they involve especially the epithelium of the convoluted tubules—the epithelium of the straight and collecting tubules being for the most part normal or but slightly altered. Desquamation is common, sometimes excessive. In some cases evidences of regeneration of the epithelium in the form of mitotic figures are present to a slight extent. Here and there the lumen of the tubules is more or less obstructed, in some places completely occluded and in consequence dilated, by swollen and desquamated epithelium, coagulated and finely granular albumin, fat granules, erythrocytes, leucocytes (mostly mononuclear), hyaline and other tube casts, and detritus. The changes in the glomeruli vary much, depending upon the severity of the process. In some mild cases they reveal little or no deviation from the normal. Usually, however, the blood-vessels of the glomerulus are dilated and overfilled with blood, in some cases with a disproportionately large number of leucocytes that may present fatty degeneration and fragmentation of the nuclei. The endothelium of the vascular tuft is frequently swollen and proliferating (intracapillary glomerulitis), and this, together with the very common hyaline thrombosis, gives rise to considerable obstruction to the blood current, and seriously compromises the nutrition of the tubular structures. In some cases the cavity of the capsule of Bowman contains a small amount of an albuminoid or hyaline material that is usually crescent-shaped. In more severe cases, in addition to the foregoing, both degenerative and proliferative changes in the epithelium of the capsule occur (Fig. 3063). These implicate both the epithelium of the glomerulus as well as that lining the capsule. Usually both are implicated, though the changes in the capsular epithelium may be much the less marked. The degenerative changes are similar to those that affect the tubular epithelium. The proliferation of the epithelium is sometimes so marked as to warrant the term *proliferative* or *desquamative glomerulitis*. In severe cases the capsule is filled with, and the vascular tuft is compressed by, an exudate that consists of proliferated and desquamated epithelium, coagulated albuminoid or hyaline material, cell detritus, erythrocytes, leucocytes, fat droplets, etc. (Fig. 3064). In hemorrhagic cases intracapsular extravasation of blood may be excessive. In consequence of desquamation of the glomerular epithelium and of changes in the capillary loop itself the permeability of the vessels becomes increased and the albuminous constituents of the blood find their way into the urine. In other cases, in consequence of more destructive changes the glomerulus is rendered entirely functionless. The changes in the interstitial tissue vary much in different cases. In cases of toxic or degenerative nephritis they may be entirely or almost entirely absent. Usually, however, there are dilatation of the blood-vessels, swelling and œdema of the interstitial tissue (especially in septic cases)—whence the tubules appear more widely separated than in health—and cellular exudation (Fig. 3065). The cellular exudation consists of emigrated leucocytes (mostly mononuclear), erythrocytes, proliferated fixed connective-tissue cells, and plasma cells. In most cases this exudate is confined to the cortex through which it is distributed more or less uniformly, or, as is more frequently the case, it is collected in more or less circumscribed foci. Usually it is more marked about the interlobular veins and the stellate veins, at the inner boundary of the cortex, and about the Malpighian capsules. In severe cases, hemorrhages may occur, not only into the Malpighian capsules and the tubules, as already mentioned, but also into the interstitial tissues. These are especially common in the nephritis known as *acute hemorrhagic nephritis*.

Fig. 3062.—Fatty Degeneration of the Epithelium of the Convoluted Tubules of the Kidney. The fat droplets are stained black with osmic acid. (Delafield and Prudden.)

(c) ACUTE INTERSTITIAL NON-SUPPURATIVE NEPHRITIS is "an acute inflammation of the kidney characterized by cellular and fluid exudation in the interstitial tissues, accompanied by, but not dependent on, degeneration of the epithelium; the exudation is not purulent in character, and the lesions may be both diffuse and focal" (Councilman). This form of nephritis, which occurs in the infective diseases, especially in scarlet fever and diphtheria, but also in typhoid fever, etc., was described first by Biermer, and later by Wagner, who gave it the name of acute lymphomatous nephritis. More recently it has been studied by Councilman, who states: "The disease is characterized by general and focal infiltration of the interstitial tissue of the kidney with cells which correspond to those which Unna has described under the name of plasma cells. The focal character of the infiltration is marked: even in cases in which all the parts of the kidney show some interstitial cellular infiltration, the cells are most abundant in certain foci. These foci are found in three places: in the boundary zone of the pyramids, in the subcapsular region of the cortex, and around the glomeruli. A considerable number of cases is found in which the blood-vessels of the boundary zone of the pyramids contain numbers of lymphoid and plasma cells without any infiltration of the interstitial tissue. The new cells in the interstitial tissues are due to emigration from the blood-vessels and multiplication by mitotic division of the cells which have emigrated. The cells can emigrate as plasma cells or as lymphoid cells, and the latter may change into plasma cells in the tissues. . No adequate explanation is found for the focal character of the lesions in the kidneys."

FIG. 3063.—Acute Diffuse Nephritis. Swelling of the cells covering the capillary tufts and lining Bowman's capsule. (Delafield and Prudden.)

(d) THE KIDNEY OF PREGNANCY is a peculiar condition of the kidneys occurring in pregnant women—a condition to be distinguished from a nephritis antecedent to the pregnancy, and a nephritis occurring in the course of pregnancy and attributable to the etiological factors already mentioned. It develops especially in the second half of pregnancy, in young primiparæ, and in twin pregnancies. Its nature is not understood. It has been ascribed to increased intra-abdominal and intrapelvic pressure exerted especially on the renal veins, on the ureters, and on the cœliac ganglion (occasioning renal anæmia in consequence of reflex contraction of the renal arteries); to bacterial infection and toxæmia; to auto-intoxication—the consequence of the inability of the kidneys to serve as emunctories for both the mother and the fœtus, etc. Writers are not agreed as to whether the lesions are purely degenerative or degenerative and inflammatory. The kidney varies in appearance in different cases and it is scarcely to be distinguished from some cases of acute diffuse nephritis. It is usually enlarged, its capsule strips readily, revealing a smooth, pale, usually yellowish surface. On section the cortex is somewhat swollen. Microscopically the most conspicuous lesions are retrograde changes similar to those already mentioned. Usually the lesions in the interstitial tissues are slight.

Symptoms.—Acute toxic or degenerative nephritis may run its usually short and benign course entirely devoid of symptoms and without noteworthy alterations in the urine. The general manifestations of the intoxication or infection that gives rise to the kidney lesions may be not in the least aggravated. Slight dull pain in the lumbar regions may be complained of, but the morbid condition

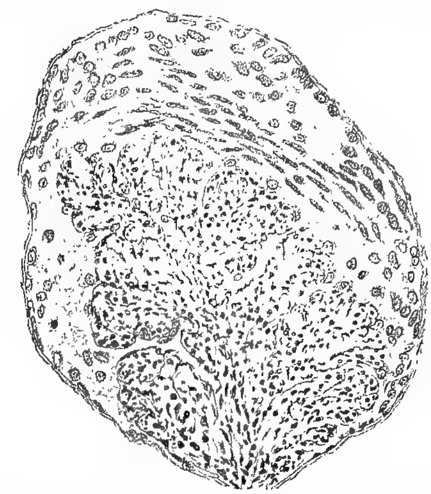

FIG. 3064.—Acute Diffuse Nephritis Following Scarlatina. Swollen cells are seen upon the capillary tuft and lining Bowman's capsule. Polyhedral and flattened cells lie in masses between the capsule and the tuft, the latter has been pressed upon by the cells and other exudate within the capsule. (Delafield and Prudden.)

of the kidneys is detected only by examining the urine. The development of slight albuminuria during the course of any of the well-known infective diseases warrants the assumption of the existence of such toxic degeneration of the renal epithelium—a condition usually recognized clinically as *febrile albuminuria*. The albuminuria, however, is probably due to the action of a toxin rather than to the fever, though this may be a contributing factor. The urine in these cases reveals the characteristics of febrile urine generally: it is diminished in amount, tur-

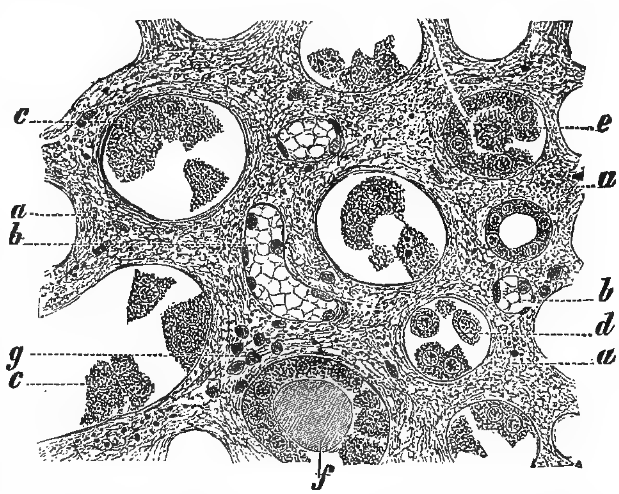

FIG. 3065.—Acute Diffuse Nephritis, with Sero-fibrinous Exudate and Catarrh of the Uriniferous Tubules (from a man who died of suppurative mediastinitis and pleuritis with nephritis on the tenth day after the beginning of the disease). *a*, Stroma distended by fluid and infiltrated with granules, filaments of fibrin, and several fat droplets; *b*, capillaries; *c*, epithelium of the convoluted tubules, in part fatty and desquamating; *d*, desquamated epithelial cells in a looped tubule; *e*, granular and fatty detritus in a looped tubule, the epithelium of which still remains but is the seat of cloudy swelling; *f*, hyaline tube cast in a convoluted tubule; *g*, round cells. × 350. (Ziegler.)

bid, of high color, increased specific gravity (1.022 or more), and markedly acid in reaction; it contains an excess of solids and a small amount or merely a trace of al-

bumin; and it deposits a slight sediment that contains a few leucocytes and usually a few hyaline tube casts. With cessation of the toxic or infective process the urinary conditions revert to the normal. In severe cases, such as may occur in cholera, corrosive-sublimate poisoning, cantharidal poisoning, etc., anuria may develop speedily and lead to a fatal termination.

Acute diffuse nephritis may develop more or less insidiously in the course of some one of the infective diseases, or it may come on suddenly, as, for instance, after a debauch and exposure to the inclemencies of the weather. In either case its existence is revealed by œdema or by changes in the urine or by both. The general symptoms are by no means characteristic. If the disease develops after a debauch and exposure, there may be sudden and rather high fever (101°–103° F.), associated or not with chilliness, pain in the back, and possibly nausea and vomiting. If it develops during the course of one of the infective diseases, the fever of the infective disease may be not in the least disturbed. Frequently, however, there is some increase in the fever. In general, children, rather than adults, are likely to have fever, especially in scarlatinal nephritis. In these cases the fever is usually moderate, and it may last for from several days to a week. An initial convulsion in children is not uncommon. Local symptoms, such as lumbar pain and tenderness, frequent micturition, vesical tenesmus, etc., may be present, though they are frequently absent.

Œdema is one of the characteristic signs of acute nephritis. Though it may be detected by careful examination in some cases in which it is thought to be absent, it is not invariably present. Its absence in some of the cases of nephritis, in some of the cases of severe nephritis that occur during the course of infective diseases, such as diphtheria, typhoid fever, pneumonia, sepsis, etc., is noteworthy and suggests the wisdom of frequently examining the urine. It sometimes comes on slowly, the patient becoming gradually swollen and pale; in other cases it develops suddenly, coming on within twenty-four hours of the onset of the disease, and constituting the earliest and most obtrusive sign, especially after a debauch, in scarlet fever, etc. Usually it develops coincidentally with, rarely before, the lessening in the quantity of urine. It varies much in degree in different cases, and it bears no relationship to the amount of the urine or to the amount of albumin. Usually it develops first in the eyelids; then in the face generally; then about the ankles, in the hands, in the legs, scrotum, and the loose and areolar and dependent portions of the body generally. Finally the œdema becomes universal, and hydropsical effusions occur within the several serous cavities of the body. Rarely the serous cavity effusions develop before the cutaneous œdema. Œdema of the mucous membranes is not common, though œdema of the glottis is by no means rare. Œdema of the palate, conjunctiva, etc., is less frequent. Œdema of the lungs is not uncommon, especially if the case progresses to a fatal termination. Œdema of the meninges, which is less common than is maintained by those that look upon it as the cause of uræmia, does occur, and has been confounded with hemiplegia, etc. The œdema in general is probably due, as maintained by Senator, to the action of certain poisons on the blood-vessels (especially the capillaries) and the lymphatics. Senator supports his view by pointing out that in scarlet fever, in which disease the cutaneous capillaries are especially implicated, he as well as others has observed the occurrence of cutaneous œdema without nephritis.

The pathognomonic signs of acute nephritis are furnished by the urine, and the changes in the urine are an index of the seriousness of the lesions of the kidneys. Frequently the first sign to attract attention is diminution in the daily amount of urine. Commonly the daily amount is 300 c.c., or thereabout, though in the beginning of many cases it is less than 100 c.c. In some cases complete anuria supervenes and may lead rapidly to a fatal termination. The urine is acid in reaction, highly colored (smoky, rarely bright red—from the presence of considerable blood), turbid, and of increased specific gravity—1.024 to 1.030. In some cases, however, on account of great deficiency in the excretion of solids, the specific gravity may be rather low. Though the percentage of urea may be increased, the total quantity of urea as well of other nitrogenous substances is diminished; uric acid may be normal in amount, and the purin bases usually are increased. The urine always contains albumin, generally from 0.3 to one per cent., or 5 to 10 gm. daily. The albumin is the albumin of the blood serum—serum albumin and globulin; sometimes also nucleoalbumin (especially when a considerable number of cells are present), and rarely albumoses. Usually an abundant, sometimes hemorrhagic sediment is deposited. This consists of erythrocytes, leucocytes (mostly mononuclear), renal and bladder epithelium (single cells or cells in masses); crystals of uric acid and oxalates; hyaline, epithelial, granular, leucocyte, and blood casts; compound granule cells, cell detritus, bacteria (not always referable to extraneous contamination), etc. In different cases there is frequently a preponderance of one or another of these morphological elements, as, for instance, of erythrocytes and blood casts in acute hemorrhagic nephritis, and of renal epithelium and epithelial casts in cases attended with considerable desquamation, etc. Sometimes blood pigment in the form of granules or larger masses is encountered. This pigment may appear independently of erythrocytes, especially in cases in which hæmolysis or hæmoglobinæmia occurs, as, for instance, in certain of the infective diseases—typhoid fever, scarlet fever, malaria, yellow fever, etc.; in certain of the intoxications and following burns; and in the new-born infant. Recently some diagnostic importance has been attributed to cryoscopy, or the determining of the freezing point of the urine. Thus it has been found that the freezing point of normal urine is from 1.3° to 2.3° C. below that of distilled water, whereas the freezing point of the urine in nephritis is only 1° C., or less than 1° C., below that of distilled water. These differences depend upon the molecular concentration or osmotic pressure of the urine which is less in nephritis (hyposthenuria) than it is in health. With improvement in the condition of the kidneys, especially with the absorption of dropsy, if such were present, considerable increase in the daily amount and diminution in the specific gravity of the urine occur. This is frequently the first encouraging sign in the case.

In addition to the foregoing, few symptoms are of much diagnostic significance. The pulse, as a rule, is full and of increased tension, somewhat slowed in the early stages, and somewhat accelerated in the later stages. Hypertrophy of the left ventricle of the heart and accentuation of the aortic second sound may develop after the lapse of several (usually four to six) weeks. In children these sometimes develop unusually early. Epistaxis is a suggestive symptom in some cases. Dyspnœa, due to hydrothorax or hydropericardium, diffuse bronchitis, œdema of the lungs, or catarrhal pneumonia, is not uncommon, especially if the case progresses to a fatal termination. The appetite is poor; the bowels are confined, though sometimes there is diarrhœa; and vomiting is not rare. If vomiting persists, it is of bad augury, presaging the onset of more serious uræmic symptoms. The nephritic patient usually becomes rapidly anæmic and loses flesh, though the wasting is more or less concealed by the œdema. The blood usually is hydræmic and of lessened specific gravity; there is moderate oligocythæmia, and usually disproportionate oligochromæmia (moderate chlorotic anæmia). The leucocytes usually are normal in number, though a leucocytosis (16,000 to 22,000 per cubic millimetre), has been observed in a number of cases, especially severe cases of acute hemorrhagic nephritis, in uræmia, and in complicating infections. The blood becomes toxic, especially in uræmic conditions; increased viscosity has been observed, and according to some investigations the freezing point of the blood is higher than normally on account of the accumulation of waste products.

Uræmia is a term applied to a symptom complex, con-

sisting largely of cerebral and gastro-intestinal symptoms, that occurs in the course of disease of the kidneys and in anuria, and that is referable to intoxication of the system with certain metabolic products that should be, and in health are, eliminated by the kidneys. The exact nature of the poison, whether there be one or several poisons, and whether the same poison or poisons are operative in all cases, have not yet been determined. The poison cannot be urea, uric acid, the potassium or sodium salts, creatinin, or certain other well-known constituents of the urine, since the injecting of each of these substances singly into the circulation does not give rise to uræmia. It has been attributed to a supposed internal secretion of the kidneys, in proof of which it has been pointed out that removal of a portion of one kidney results in considerable increase in the production of certain nitrogenous excretives. It has been attributed to œdema of the brain and meninges, but this view (Traube's) is no longer tenable. It has been attributed also to certain "urotoxins" (Bouchard), to acid intoxication (diminution in the alkalinity of the blood), to the toxæmia of the blood that has been found by Hughes and Carter, Herter, and others, to be present in uræmia, etc. All that can be said with certainty is that it is an intoxication of the system with certain metabolic products that in health are eliminated by the kidneys. These substances exert their deleterious action chiefly on the brain where they probably damage the nerve cells directly, though they may also influence the blood supply.

Uræmia is an unwelcome event that may develop in any case of nephritis. As a rule it develops only when the daily amount of urine voided is very much diminished or when there is complete anuria. In some such cases, however, uræmia does not occur, a fact compatible only with the hypothesis that the other emunctories have taken on vicarious action, or that the amount of toxic materials accumulating in the system is very small. On the other hand, uræmia sometimes develops in cases in which large amounts of urine are being voided. These cases are sometimes difficult to explain, though doubtless there has been a gradual accumulation of small amounts of the uræmic poison, and then a sudden explosion alike to that which occurs in some cases of mineral poisoning, such as mercury, lead, etc. This is not uncommon in some cases of chronic diffuse indurative nephritis (primarily contracted, or red granular kidney). In some of these cases, however, the uræmia is referable to cardiac weakness with consequent lessening of the blood pressure and diminution in the amount of urine excreted. In other cases uræmia is coincident with the absorption of œdema.

Clinically uræmia may be acute or chronic. The acute form is especially common in acute and chronic diffuse non-indurative nephritis, whereas the chronic form is especially common in chronic diffuse indurative nephritis. Acute uræmia, usually preceded by certain subacute or chronic prodromes, such as headache, insomnia, breathlessness, restlessness, etc., comes on suddenly, lasts but a short time, and frequently terminates fatally. Chronic uræmia, on the other hand, is more insidious in its onset and more mild in its manifestations; it may last for a comparatively long time, disappear, and subsequently recur. The uræmia that occurs in obstruction of the ureters and that sometimes differs in its manifestations from the ordinary cases of uræmia, has been described as "latent uræmia."

The characteristic symptoms of acute uræmia are nervous in nature and consist of convulsions, coma, psychic derangements, etc. The convulsions resemble a true epileptic fit, and they are frequently exceedingly severe (uræmic eclampsia). They may or may not be preceded by prodromes; the initial cry of true epilepsy is usually absent. The convulsions may be local or unilateral, and finally general. Aside from the coma that attends the convulsions, there is a coma that is quite independent of convulsions. It usually comes on insidiously, being preceded by certain less serious uræmic manifestations, such as headache, apathy, dyspnœa, muscular twitchings, etc. Muscular twitchings are also common during the persistence of the coma, which may last for days, even weeks, and eventually disappear. Usually, however, the patient passes into a typhoid state and finally dies. The psychic derangements are melancholia, delusional insanity, mania which may develop suddenly, become exceedingly wild, and lead rapidly to a fatal termination, etc. In some cases the fatal termination is ushered in with a hemiplegia or a monoplegia that at the necropsy may be found to be due, not to intracerebral hemorrhage, but solely to œdema of the meninges and anæmia of the brain. The milder and chronic manifestations of uræmia, which frequently exist for a few days, in some cases even for years before the onset of the severer acute symptoms, consist of headache (often occipital), hemicrania, vertigo, tinnitus aurium, insomnia, a feeling of anxiety, muscular twitchings, languor, neurasthenia, pains in the joints or muscles, nocturnal cramps in the calves, etc. Amaurosis is not uncommon. It may or may not be associated with convulsions, though it usually follows convulsions. It is attributable to disorder of the cerebral visual centres. Usually it subsides after several days. Deafness and aphasia are rather rare. Uræmic dyspnœa or renal asthma is one of the most suggestive manifestations of chronic uræmia. It is frequently one of the earliest obtrusive symptoms of chronic nephritis, and it should always suggest the wisdom of examining the urine. It may be continuous, when it should always attract attention; it may be paroxysmal, coming on especially at night; and it may manifest itself by Cheyne-Stokes breathing. It is usually a manifestation of toxæmia, though it may be due to, or augmented by, hydrothorax or hydropericardium, diffuse bronchitis, œdema of the lungs, catarrhal pneumonia, etc. Persistent and uncontrollable vomiting, usually associated with nausea, is especially suggestive of chronic nephritis. It may be of centric origin the result of toxic irritation of the medullary centres, or it may be the result of gastric irritability produced by the excretion by the gastric mucosa of urea and its decomposition into ammonia. Profuse diarrhœa, associated with catarrhal and ulcerative enteritis and colitis, is rather common. Stomatitis, attributed to the elimination of urea by the saliva and the sputum, is observed rather frequently. In uræmia the breath frequently has a urinous or an ammoniacal odor, and crystals of urea eliminated by the sweat glands may be observed on the skin, especially about the normal folds where they sometimes lead to eczema. The pulse usually is slow and of increased tension, but with the supervention of convulsions it becomes small, rapid, and feeble. The temperature is usually subnormal, though a uræmic fever, occurring apart from the fever generally present during the convulsions, as well as uræmic chills, has been described.

Diagnosis.—The diagnosis of acute nephritis, frequently suggested by the history of the case and the occurrence of œdema, is based upon the results of an examination of the urine. Frequent examinations of the urine, therefore, should be made in all cases of disease, but especially in all cases likely to be attended by nephritis, as for instance, all the infective diseases, intoxications, and during pregnancy. The urine of all patients presenting pallor of the skin and even slight swelling of the eyelids should also be examined, and one should bear in mind that the first manifestation of nephritis may be a uræmic convulsion or coma. In all cases of convulsion and of coma, therefore, the urine should receive immediate attention, and catheterization, if necessary, should be performed at once. Whether the kidney lesion be an acute nephritis or an acute exacerbation of a chronic nephritis may be determined in part by the history of the case, and in part by examining the urinary sediment. From the sediment also one may glean an idea of the nature and severity of the renal lesions. Acute interstitial non-suppurative nephritis is not recognizable clinically; that is, the symptoms to which it gives rise do not differ from the symptoms of acute diffuse nephritis.

Course and Prognosis.—Acute toxic or degenerative nephritis occurring in the course of some infective disease usually runs a mild course and subsides with the in-

fective disease in question. In some cases, however, especially in cholera, yellow fever, some cases of typhoid fever, etc., as well as in certain intoxications, such as corrosive-sublimate poisoning, phosphorus poisoning, etc., it either leads directly to the death of the patient (possibly by producing anuria), or it contributes to the fatal termination. Acute diffuse nephritis of mild or moderate severity usually runs its course in from several days to four or six weeks. Probably more than one-half of the patients recover; the remainder die or the kidney lesions progress to chronic diffuse non-indurative nephritis. The termination depends in great measure upon the cause of the nephritis and upon the severity of the lesions. In favorable cases improvement is usually manifest at the end of ten days. In all cases the prognosis is anxious, and it is materially influenced by the occurrence of complications, such as secondary infections, internal dropsies, inflammations of the serous membranes, catarrhal pneumonia, œdema of the lungs, etc. The prognosis is very bad in cases with extreme anasarca or marked uræmia that does not respond promptly to treatment—though both of these conditions may be followed by recovery. There is always danger of a fatal termination in the kidney of pregnancy, but recovery ensues in the majority of cases when delivery has been effected.

Treatment.—The natural history of acute nephritis furnishes clear indications for treatment, the principal of which are: (1) To secure temporary physiological rest for the kidneys, and to guard against the dangers that threaten from accumulation of waste products in the system, by promoting the activity of the other emunctories; (2) to lessen the inflammatory phenomena in the kidneys; and (3) to meet the symptomatic indications, such as uræmia, pulmonary œdema, hydrothorax, etc., as they arise.

The prophylaxis deserves some consideration. It is said that an attack of acute nephritis, such, for instance, as follows scarlet fever and other infective diseases, and the imminence of which is manifest by hæmaturia and increased arterial tension, may be averted by a brisk purgative—a full dose of a saline cathartic or of compound jalap powder. In other cases, cases in which it is known that acute nephritis may develop, such as the acute infective diseases, etc., measures should be adopted early to guard against the occurrence of the renal complication. These comprise the avoiding of exposure to weather inclemencies, the using of suitable personal and bed clothing, the prohibiting of irritating food and drink, the promoting of the functional activity of the other emunctories (the skin and the intestines), the diluting of the toxic material in the body by the use of large quantities of water, etc.

In most cases, however, we have to deal with the developed disease. Our first endeavor should be to secure for the patient rest, warmth, and a suitable diet, under the beneficent influence of which many of the milder cases subside. In all cases, even the very mild cases, absolute rest in bed is imperative. The rest must be prolonged until all indications of the disease have disappeared. It is advisable that the patient wear light flannels and that he rest between blankets: the flannels promote the functional activity of the skin and the absence of sheets lessens the risk of chill. The diet should be as non-nitrogenous as possible and as small in amount as is compatible with preserving the strength of the patient. Milk is the most suitable diet and should constitute the sole diet for some days at least; in case it be well borne and the patient do not object too strenuously no other diet may be given for some weeks. The milk may be given warm, if relished so. Whole milk may be given, or it may be diluted one-third with lime water (which serves to decrease the acidity of the urine), or with hot water, or some carbonated water, or some thin oatmeal gruel. Its (to some people unpleasant) taste may be disguised by the addition of a small amount of strong black coffee, a little salt, or a little extract of vanilla. As occasion requires, buttermilk or skimmed milk may be substituted in whole or in part. The milk should be given in small amounts at frequent intervals rather than in large amounts at longer intervals. The free use of bland fluids, such as ordinary water, is extremely serviceable; they serve to allay thirst and to flush the kidneys. Sodium bicarbonate, potassium citrate, or sodium benzoate, in the proportion of five to ten grains to the ounce, may be added to the water. A pleasant drink consists of a drachm of cream of tartar and the juice of half a lemon added to a pint of boiling water, and used when it has cooled. Weak lemonade and thin arrowroot also are permissible.

Local depletive measures are of some service, tending as they do to relieve the engorgement of the kidneys. They should not be neglected in cases that begin with much local distress, hæmaturia, or marked suppression of urine. Probably the most serviceable measure is free dry cupping (a dozen or more cups). They should not be allowed to remain until stagnation of the blood in the capillaries has occurred, as the object of their use may be thus defeated. They may be followed by hot linseed poultices which should be frequently renewed before they have cooled. The poultices may be used instead of the cups as occasion seems to warrant. In case the nurse is not trustworthy it is well to substitute a hot woollen jacket for the poultices, as the risk of chilling is thus reduced. In some cases the Paquelin cautery will be found of service.

Temporary and partial physiological rest for the kidneys is secured, and the dangers that threaten from the accumulation of waste products in the blood are counteracted, in part at least, by promoting the functional activity of the skin and the intestinal tract, by the use of diaphoretics and of purgatives. The activity of the skin is best promoted by hydrotherapy—by the hot-water bath, the hot-air bath, the hot-vapor bath, and the hot wet pack. In adults any one of these forms of hydrotherapy may be employed with confidence, though probably the hot-water bath or the hot wet pack are the easier of application. In children the hot wet pack is usually serviceable. The sweating induced by these measures is usually profuse and non-exhausting. In cases in which the first use of these hydrotherapeutic measures is unattended by the desired sweating, the procedure should be repeated in a short time. In many cases the sweating is induced or augmented by the concurrent administration to the patient of a hot drink or of a diaphoretic mixture, such, for instance, as contains spirits of nitrous ether, solution of the acetate of ammonium, etc. A Dover's powder may answer the same purpose. In urgent cases, pilocarpine, alone or in conjunction with hydrotherapeutic measures, should be used. The pilocarpine may be given in doses of gr. $\frac{1}{8}$ or gr. $\frac{1}{6}$ hypodermically, and repeated in half an hour, if necessary. Caution, however, is necessary in its employment; no more should be given than is required, and it should be avoided in children. Its depressing effect, as well as the depression that sometimes attends the use of hydrotherapeutic measures, calls for the administration of stimulants. In serious cases the bath should be repeated daily; and less frequently in less serious cases, and as convalescence becomes established. In some cases gentle and continuous sweating is effected by the administration of fluid extract of jaborandi, ♏x. to xv. to an adult, every two to four hours.

Free purgation is called for in all cases—whether or not constipation exists. At the outset of the treatment, it is generally well to administer sufficient of a concentrated solution of some saline cathartic to secure several watery evacuations. In cases with gastric irritability, the effervescing preparations will be found of service. Compound jalap powder (gr. xxx.) may be substituted for the saline. In many cases calomel is found to be a very efficient cathartic, but it is well to avoid it in the early stages of severe attacks since, on account of its diuretic action, it tends to increase the already existing congestion of the kidneys.

The question of the use of diuretics is still debated. However, stimulating diuretics, since they act by pro-

ducing congestion of the kidneys, are assuredly contraindicated in the early stages of a severe attack of acute nephritis. The very best diuretic is water, which, merely flushing the kidneys, facilitates the removal of the products of inflammation and desquamation from the kidneys, reduces the acidity of the highly acid and irritating urine, and dilutes the toxins present in the blood. The alkaline diuretics already mentioned may often be employed with hope of good result. The more stimulating diuretics, such as digitalis, strophanthus, caffeine, cocaine, etc., which increase the blood pressure, should be reserved for a later date when they may render very valuable service. In many cases when the blood pressure is low and the heart action is weak, the happiest results are obtained by the combination of digitalis (preferably the infusion) with the alkaline diuretics. Diuretin and theobromine also may be found of service. The iodide of potassium has been recommended.

With the onset of uræmia treatment must be energetic. Inasmuch as in many cases of uræmia the blood pressure is increased the first indication is to bleed the patient. The extraction of from ten to twenty ounces of blood from the arm of the patient removes a considerable quantity of the poison, and the subsequent injection of a pint or two of decinormal saline solution serves to dilute the poison that remains. Serviceable in all cases, these two procedures should not be delayed in the event of convulsions or coma. If the convulsions are violent they should be controlled by the inhalation of chloroform. The convulsions that attend *acute* nephritis may often be satisfactorily controlled by the hypodermic injection of a quarter of a grain of morphine—a method of treatment successfully employed for many years by the late Professor Loomis. Free and immediate evacuation of the bowels must be secured, preferably by the use of one or two drops of croton oil, diluted or not with a little olive oil or glycerin, placed on the back of the tongue, or by the administration of a quarter of a grain of elaterium in solution. At the same time a stimulating enema should be given. Profuse perspiration should be induced as soon as possible, preferably by the use of a hot wet pack or a hot vapor bath and by the hypodermic injection of pilocarpine. After the thorough evacuation of the bowels, if the convulsions have not ceased, they may be controlled by the rectal administration of chloral (gr. xxx.-xl.) and potassium bromide (ʒ i.). In some cases imminent uræmia, due to cardiac insufficiency, may be warded off by the free use of cardiac stimulants, such as digitalis and strychnine, diffusible stimulants, such as camphor (hypodermically), hypodermoclysis, and a calomel or saline purge.

Certain special symptoms sometimes demand attention. Thus vomiting and diarrhœa may be marked. Generally manifestations of uræmia, they often subserve a useful purpose, and should not always be unceremoniously stopped. When vomiting gives rise to marked weakness, small bits of cracked ice or sips of very hot water may be given. In addition counter-irritation to the epigastrium and the internal administration of bismuth, creosote, and lime water, or dilute hydrocyanic acid, or carbolic acid, etc., may be tried. Extreme dropsy that does not yield to the measures already detailed may necessitate small incisions in the skin or the use of Southey's tubes. Dropsy of the serous cavities may require tappings. Headache not relieved by general depletive measures may demand the use of bromides, etc. Pulmonary œdema, catarrhal pneumonia, and other complications are to be treated on general principles.

During convalescence extreme care must be exercised to avoid chill and a possible relapse. The increase of diet must be gradual—first farinaceous foods may be permitted, then light vegetables, non-acid fruits, and finally light meats, etc. Flannels should be worn next the skin, and the resumption of exercise must be gradual. In combating the anæmia and weakness so common during convalescence iron is useful, but it should not be employed until all acute manifestations have subsided. The liquor ferri et ammonii acetatis (Basham's mixture) enjoys a well-deserved popularity, and may be combined with strychnine. The limitations of our therapeutic resources are sometimes only too apparent from our inability to control the single obtrusive symptom of the disease that may remain—the albuminuria. Lactate of strontium, which has been recommended for this, continues to merit trial. Residence in a warm, somewhat humid, equable climate is to be recommended to those able to avail themselves of its advantages.

II. Chronic Nephritis.

(*a*) Chronic Diffuse Non-Indurative Nephritis.—*Etiology and Pathogenesis.*—In many respects no sharp line of demarcation can be drawn between acute nephritis and chronic diffuse non-indurative nephritis, on the one hand, and between chronic diffuse non-indurative nephritis and chronic diffuse indurative nephritis, on the other hand. In many cases they doubtless represent different stages of the same process. However, chronic diffuse non-indurative nephritis is most common in young male adults between the ages of twenty and forty years; but it is not rare in women, and in children, especially after scarlet fever. In many instances it follows acute nephritis, so that its etiology and pathogenesis are not to be divorced from the etiology and pathogenesis of acute nephritis. Probably, however, in the majority of cases it develops insidiously, subacutely or chronically, being the expression of the action of toxic or infective agencies insufficient in amount or virulence or both to give rise to acute nephritis. Malaria, for instance, is more likely to result in this chronic non-indurative nephritis than it is in acute nephritis. The disease is also attributable to continued exposure to the inclemencies of the weather, to insanitary surroundings, to over-indulgence in alcoholic beverages, etc. It is common in tuberculosis, syphilis, and prolonged suppuration, in which cases it is frequently associated with amyloid disease of the kidneys and of other organs. It occurs also in chronic heart disease apart from the cases of cyanotic induration. Though it runs an essentially chronic course, acute exacerbations are common.

Pathological Anatomy.—In nature the anatomical lesions in acute and in chronic diffuse non-indurative nephritis are alike; they differ only in intensity and in the presence, in the chronic nephritis, of certain secondary lesions the development of which requires time. As in the acute process, so also in the chronic process, the kidneys present quite different appearances, depending upon the conspicuousness or subordinateness of certain lesions. Usually two kinds of kidneys are described—the large white (more properly yellow) kidney and the large red, mottled, or variegated kidney. The *large white kidney*, as the name implies, is at least as large as a normal kidney; frequently it is considerably enlarged. The capsule is thinned and non-adherent. The surface is smooth, pale, yellowish or mottled grayish-yellow or reddish-yellow in color. The stellate veins are usually more or less distended and some foci of hemorrhage may be apparent. On section the cortex is swollen, pale, yellowish or reddish-yellow in color, somewhat opaque, sometimes distinctly fatty, and diminished in consistency. Usually the pyramids are slightly congested, or at least darker in color than the cortex. The *large red, mottled, or variegated kidney*, the kidney of *chronic hemorrhagic nephritis*, though enlarged, scarcely attains the extremes of size common to the large white kidney. In many respects the kidney resembles the kidney of acute nephritis, being, however, much firmer. The capsule is thinned and in general non-adherent. The surface is smooth, grayish-red or very dark reddish-brown or hemorrhagic in color. Frequently it is mottled—irregularly shaped, pale, yellowish, anæmic, and fatty areas commingling with darker reddish-brown and hemorrhagic areas. On section the cortex is swollen, grayish-red in color, or mottled and striated, and darker in color. The pyramids usually are congested. Sometimes the organ is more or less translucent on account of associated amyloid disease.

Should the patient survive two years or more the kidneys gradually assume the appearances that will be described under the heading, Secondary Chronic Interstitial Nephritis.

Pathological Histology.—Microscopically the lesions affect the glomeruli, the tubules, and the intertubular connective tissue (Fig. 3066). On account of the intensity of the lesions in the glomeruli the process has been spoken of as *chronic glomerular nephritis.* The changes in the glomeruli, which vary much in intensity in different cases, in general resemble the changes found in acute nephritis, being both proliferative and degenerative in character. The proliferative changes involve the epithelium as well as the cells of the vascular tuft, and in consequence the cavity of the Malpighian body becomes more or less filled with an exudate similar to that present in acute nephritis. The degenerative changes consist of fatty and hyaline transformation of the epithelium and the endothelium of the capillaries. In consequence of these alterations the glomerulus usually is rendered completely functionless—a process that is accomplished also by the so-called adhesive glomerulitis, recently described by Engel. Amyloid degeneration of the vascular tuft also is quite common. The conspicuous lesion in the tubules is fatty degeneration, which involves especially the epithelium of the convoluted tubules, although the epithelium of the straight tubules is usually affected also. In addition, the other retrograde alterations mentioned in connection with acute nephritis are present to some extent. The lesions may be uniform throughout the kidney, but they are commonly focal in character. It is in consequence of the marked fatty degeneration of the epithelium and of the anæmia induced by the pressure exerted on the blood-vessels by the desquamated and degenerated cells and detritus in the obstructed tubules that the pale and fatty color of the kidney is brought about. The changes in the connective tissue do not differ essentially from those present in acute nephritis. In the one case there is considerable fatty degeneration and infiltration, in the other considerable hemorrhage; but both are present in varying degree in all cases, especially in the chronic hemorrhagic nephritis and in acute exacerbations of chronic nephritis. As the disease advances the cellular exudate becomes converted into newly formed fibrous connective tissue which by contracting leads to atrophy of the glomeruli and tubules. The earliest formation of such new fibrous connective tissue is usually about the capsule of Bowman. With increase in the formation of such fibrous connective tissue the appearances to be described under the heading, Secondary Chronic Interstitial Nephritis are brought about.

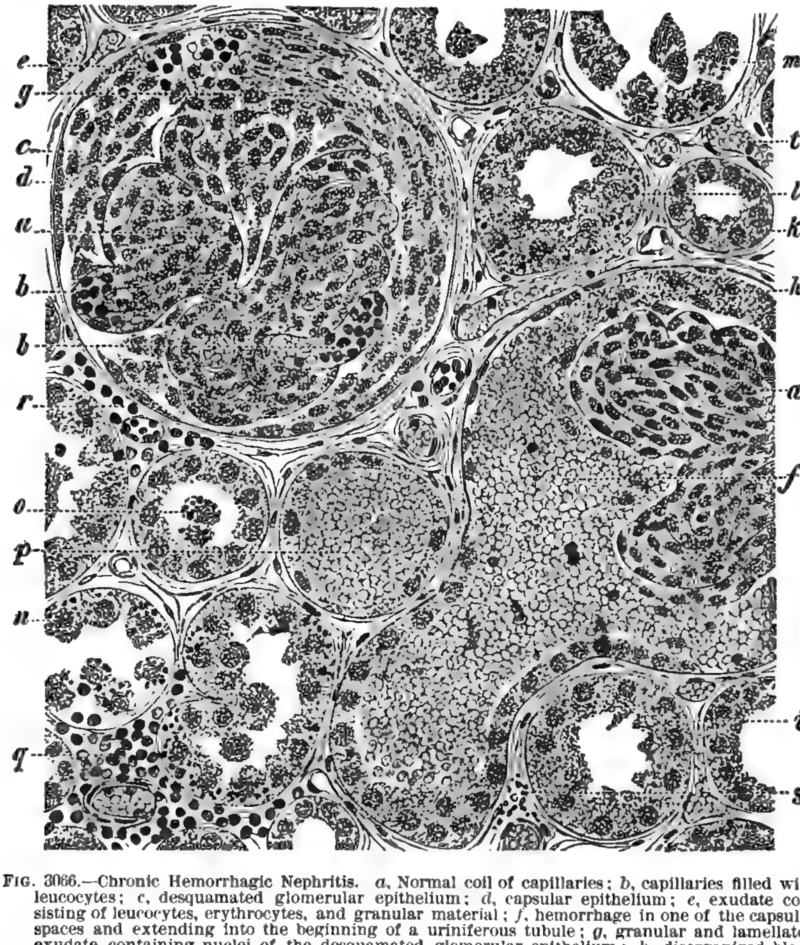

FIG. 3066.—Chronic Hemorrhagic Nephritis. *a*, Normal coil of capillaries; *b*, capillaries filled with leucocytes; *c*, desquamated glomerular epithelium; *d*, capsular epithelium; *e*, exudate consisting of leucocytes, erythrocytes, and granular material; *f*, hemorrhage in one of the capsular spaces and extending into the beginning of a uriniferous tubule; *g*, granular and lamellated exudate containing nuclei of the desquamated glomerular epithelium; *h*, disorganized blood enclosing desquamated glomerular epithelium; *i*, convoluted tubule; *k*, looped tubule; *l*, uriniferous tubule containing pigmented and fatty degenerated epithelium; *m*, pigmented epithelium desquamating; *n*, fatty and in part desquamated cells; *o*, desquamated and fatty epithelium in the lumen of a normal uriniferous tubule; *p*, tubule filled with blood; *q*, perivenous, *r*, pericapsular, cellular exudate; *s*, pigment in the connective-tissue stroma; *t*, capillary filled with blood. × 300. (Ziegler.)

Symptoms.—In some cases, clinically as well as anatomically, chronic diffuse non-indurative nephritis develops out of acute nephritis, the symptoms of the acute disorder, especially pallor, dropsy, and albuminuria, persisting. In the majority of cases, however, the chronic disease develops insidiously. Commonly no date can be assigned as the time of the onset of the disease, and the symptoms at first scarcely suggest the renal lesion. Thus the patient may complain of indigestion with periodic attacks of nausea and vomiting, or of headache, or of pallor, or of weakness on slight exertion, or of gradual failure of health with loss of flesh, etc. Finally, swelling of the feet or ankles may attract his attention; or an observant patient may notice that his urine is cloudy and reduced in amount; or puffiness of the eyelids may suggest to the physician the wisdom of examining his patient's urine; or the albuminuria may be detected in an examination for life insurance, etc. As in acute nephritis, so in chronic nephritis, the characteristic signs consist of œdema and of changes in the urine. At first the œdema is slight and present in the seats of predilection of renal dropsy—in the eyelids, about the ankles, in the pretibial regions, in the hands, etc. Except about the eyelids, the œdema is often absent in the morning after a night's rest, and it develops or increases during the course of the day. In some cases it increases gradually until it becomes extreme; in other cases it suddenly becomes extreme. In either case it may be associated with effusions within the

serous cavities of the body; though it varies much in different cases and in the same case at different times, it is always obstinate; and, having disappeared, it is extremely likely to recur. In some cases œdema is absent—the chronic hemorrhagic Bright's disease without œdema, of Wagner.

The urine is reduced in amount and, as remarked, this may be the first symptom to attract attention. Usually the daily amount varies between 300 c.c. and 700 c.c.; only rarely and then during uræmic attacks, in acute exacerbations and shortly before death, is there such marked oliguria as frequently occurs in acute nephritis. With improvement in the condition of the patient, especially coincidentally with the absorption of marked dropsy (as well as with the advent of secondary chronic interstitial nephritis), the daily amount of urine increases and may reach two litres or more. In addition the urine is acid in reaction, though it soon becomes neutral or alkaline on standing; it is turbid and of increased specific gravity (1.018–1.025), though it is lower when large amounts are voided. It varies in color, depending largely upon the concentration and the amount of blood that it contains. It always contains a considerable amount of albumin—sometimes as much as one-half or three-fourths by bulk after the boiling-and-acid test, one per cent. to three per cent. by weight, or 15 to 30 gm. in the twenty-four hours. The amount excreted is usually greater during the day than at night. The excretion of urea and other solids is always deficient. On standing, the urine deposits an abundant sediment that consists of erythrocytes and leucocytes (generally in large numbers); epithelium from the uriniferous tubules, the pelvis of the kidney, and the bladder; hyaline, epithelial, fatty, leucocyte, and sometimes erythrocyte casts; compound granule cells, free fat droplets, cell detritus, bacteria, etc. In associated amyloid disease waxy casts also are encountered.

In general, the other symptoms are similar to those encountered in acute nephritis (which have been already detailed). Uræmic manifestations are common, more particularly the chronic nervous and gastro-intestinal symptoms which frequently persist for some time, being subject, however, to remissions and exacerbations. Attacks of acute uræmia are less common than in acute nephritis and in chronic indurative nephritis. When they do occur coma rather than convulsions is likely to be observed. Debility and anæmia are usually pronounced, and both, but especially the anæmia, seem to bear some relationship to the rapidity of the course of the renal lesions—being more marked the more rapid the course. The pulse usually is of increased tension, and after the lapse of some time arteriosclerosis develops. Usually also hypertrophy of the heart supervenes. The recognition of this may be rendered difficult by the presence of considerable dropsy, but a displaced and forcible apex beat and an accentuated aortic second sound, together with the increased pulse tension, serve for its recognition, even in the absence of demonstrable percussion evidences of enlargement of the heart. Albuminuric neuro-retinitis is quite common. It is sometimes unattended by subjective symptoms, a fact readily explicable when we remember that the location rather than the extent of the retinal lesions is of significance. Involvement of the macula lutea leads to destruction of sight, and less serious lesions are commonly manifested by dimness of vision and restriction of the fields of vision.

Diagnosis.—The diagnosis of chronic diffuse non-indurative nephritis, suggested by the history of the case, the extreme pallor, and the presence of œdema, is based upon the results of an examination of the urine. The diagnosis of the disease, therefore, is easy, but the recognition of the condition of the kidneys is commonly attended by some difficulty. The large red kidney, chronic hemorrhagic nephritis, may be suspected when the urinary sediment contains a relatively large number of erythrocytes and blood casts, whereas the presence of large numbers of fatty casts, free fat droplets, and fatty or compound granule cells suggests the large white kidney. In some cases of large white kidney, in the absence of hemorrhage, the presence of considerable fat may give to the surface of urine that has stood for some time, a distinct oily lustre. The differential diagnosis between chronic diffuse non-indurative nephritis and amyloid disease of the kidneys is always difficult and sometimes impossible. Amyloid disease, however, is suggested by the etiological factors of amyloid disease, the associated enlargement of the liver and spleen attributable to amyloid disease, relatively slight œdema, slight or no hypertrophy of the heart, relatively few casts, those present being of the hyaline, waxy, and granular varieties, and the absence of uræmia and neuro-retinitis. Sometimes, however, the etiological factors of amyloid disease result in chronic diffuse non-indurative nephritis rather than in amyloid disease, and in many cases attempts at differential diagnosis can be of academic interest only since the two diseases are associated. Retardation in the excretion of methylene blue is said to occur in chronic nephritis and some diagnostic significance has been attributed to it. The means of distinction between the large white kidney and the small white kidney—the secondary chronic interstitial nephritis, will be referred to presently.

Course and Prognosis.—Chronic diffuse non-indurative nephritis manifests a tolerably uniform course, although remissions and exacerbations of the symptoms occur from time to time. The duration varies from two to three months in the cases commonly designated subacute to one and a half to two or two and a half years in the more chronic cases. Some patients, however, survive a longer period, the kidney assuming the characters of the secondarily contracted kidney. The prognosis is always bad, since death is the inevitable result. A few cases of recovery especially in children have been reported, but it is extremely doubtful that these were cases of well-developed chronic diffuse non-indurative nephritis. The prognosis is the more serious the greater the amount and persistence of the albuminuria and the œdema, the less the excretion of the urinary solids, and the more marked the cardio-vascular and retinal changes. Death is hastened by persisting and recurring uræmia and by the development of certain complications, such as intercurrent infections, inflammation of the serous membranes, catarrhal pneumonia, œdema of the lungs, etc. Under favorable circumstances contraction of the kidney occurs, the secondary chronic interstitial nephritis develops, and the subjective condition of the patient materially improves temporarily—he may even be in apparent good health.

Treatment.—In general the indications for treatment are similar to those mentioned in connection with acute nephritis, our endeavors being directed toward favoring the elimination of accumulating waste products, and improving the condition of the blood. Special symptoms are to be treated as they arise. The general hygienic and dietetic rules detailed in connection with acute nephritis are applicable in the chronic form of the disease, and the same rules govern the use of diaphoretics, cathartics, and diuretics. In combating the anæmia and the œdema Basham's mixture, Trousseau's diuretic wine, or Grainger Stewart's mixture of scoparius, digitalis, and potassium acetate will be found of much service. Strontium lactate, diuretin, sparteine, adonidin, oxygen (as recommended by Dujardin-Beaumetz), etc., may be found useful in different cases and may be employed from time to time. Probably the best results attend the use of general hygienic and dietetic measures, free daily evacuation of the bowels, a daily tepid bath, an occasional Turkish bath, the administration of iron, quinine, and strychnine, and from time to time a strictly milk diet.

(*b*) CHRONIC DIFFUSE INDURATIVE NEPHRITIS.—*Etiology and Pathogenesis.*—Three forms of chronic diffuse indurative nephritis (chronic interstitial nephritis, sclerosis of the kidney) may be distinguished: 1. Secondary chronic interstitial nephritis (the secondarily contracted kidney, the pale granular kidney, the small white kid-

ney) that develops as a sequence to the large white kidney. It has been suggested, however, that, contrary to the prevailing opinion, the small white kidney is not always preceded by the large white kidney. 2. Primary chronic interstitial nephritis (the primarily contracted kidney, the red granular kidney, the gouty kidney); and 3. Arteriosclerotic nephritis. *Secondary chronic interstitial nephritis*, being a late stage of chronic diffuse non-indurative nephritis (the large white kidney), the etiological factors in the two cases are the same. These have already been mentioned. *Primary chronic interstitial nephritis*, on the contrary, is an independent disorder. It develops in a kidney previously healthy and consists of a slowly progressing atrophy of the renal parenchyma and its replacement by newly formed fibrous cicatricial connective tissue. It is especially common after the fortieth year of life, but it may occur after the twentieth year, and it has been observed even in children. Twice as many men are affected as women. In many cases no etiological factor can be determined upon. In some cases, cases in which the disease affects the members of several generations of the same family, heredity plays a more or less important rôle. In the majority of cases the disease may be looked upon as the result of the exigencies of modern life, as the penalty of the strenuous life. The hurry and the cares, the worries and the anxieties of modern life, the nervous tension and the mental strain inseparable from large undertakings and heavy financial responsibilities, an irregular mode of life, over-eating of rich and highly seasoned foods, excessive indulgence in alcoholic beverages, and insufficient muscular exercise, combined tend to produce imperfect metabolism—the products of which being eliminated by, give rise to a progressive deterioration of, the chief emunctories of the body—the kidneys. In many cases the disease is directly attributable to certain autogenous and exogenous intoxications, of which the most important are alcohol, lead, and uric acid and the other metabolic poisons associated with gout. Although one can scarcely doubt that alcohol is an important etiological factor, it is likely that many of the cases attributed to the influence of alcohol are due rather to the excessive consumption of rich and highly seasoned foods. Certain disturbances of metabolism, especially such as are associated with certain functional disorders of the liver and are sometimes vaguely described under the caption, "lithæmia," are believed to lead to the disease. The disease also follows certain well-known infective diseases, especially syphilis, malaria, etc., and it is said to be provoked at times directly by scarlet fever, acute articular rheumatism, etc. *Arteriosclerotic nephritis* is very common in this country. Its etiology is the etiology of arteriosclerosis. Thus, while it occurs in both sexes, it is especially common in men past the fortieth year of life. It is prevalent in alcoholics, syphilitics, lead workers, those accustomed to hard manual labor, and "good livers," as well as in those subject to the exigencies of modern life. Although it constitutes the condition known as the *senile kidney*, it is by no means confined to advanced life. It is especially common in those having a tendency to arterial degeneration in whom it frequently develops early in life, being hastened by the etiological factors already mentioned.

Pathological Anatomy.—The kidney in chronic diffuse indurative nephritis varies somewhat in appearance, depending upon the variety of the disease. In the *secondary chronic interstitial nephritis* the kidney is sometimes slightly enlarged, sometimes normal in size, and sometimes considerably reduced in size; it varies in size depending upon the stage of the process. When reduced in size it is usually much increased in consistency, and the capsule is thickened and markedly adherent. When stripped of the capsule the surface of the kidney is granular, pale yellowish in color, or mottled with reddish areas. Usually many cysts varying considerably in size and filled with a clear watery or viscid fluid project from the surface. On section the cortex is much diminished in thickness, yellowish in color or mottled, and reveals many foci of fatty-degenerated epithelium. The pelvic fat is usually considerable. In the *primary chronic interstitial nephritis* the kidney is usually embedded in a large mass of firm adipose tissue. Having been extricated from this it is found to be very much reduced in size, being frequently but one-third or one-half the normal size; sometimes both kidneys together weigh less than 50 gm. The capsule is much thickened, puckered, and intimately adherent to the kidney tissue, and the blood-vessels are considerably dilated, on account of their vicarious action. On stripping the capsule the surface of the kidney is found to be markedly granular, the granules varying in diameter from 1 to 5 mm. The elevated portions are usually dark reddish-brown in color (whence the term red granular kidney), whereas the depressed portions are paler and grayer in color. Usually a number of cysts, varying in size from that of the smallest granule to that of a chestnut, and filled with clear amber-colored watery or viscid contents, project from the surface. The kidney is very firm, hard, and dense, and extremely resistant to the knife when it is sectioned. The cortex is much reduced in thickness, sometimes being scarcely 2 mm. thick. It is usually dark reddish-brown in color or mottled, paler grayish areas alternating with the darker red areas. At times small cysts are found—sometimes projecting from, and sometimes entirely within, the cortex. The pyramids are usually reduced in size, and they are darker in color than the cortex. In cases of gouty kidney uric-acid infarctions or striations of uric acid or sodium urate may be found in the pyramids. On account of the thickening of their walls the small arteries of the kidney are more or less apparent to the unaided eye. The contraction of the pyramids sometimes results in enlargement and elongation of the calices. In *arteriosclerotic nephritis* the kidney can scarcely be distinguished from the red granular kidney.

Pathological Histology.—In chronic diffuse indurative nephritis, although the lesions are widespread and involve all the structures of the kidney, the most conspicuous lesion is a considerable overgrowth of fibrous cicatricial connective tissue. In the *secondary chronic interstitial nephritis* the lesions already mentioned in connection with the large white kidney reveal the changes consecutive to overgrowth and cicatrization of connective tissue—atrophy of the secreting tissue of the kidney, more or less obliteration of the glomeruli, considerable increase in the connective tissue especially about the capsules of Bowman and about the blood-vessels, more or less arteriosclerosis and obliterating endarteritis, distended and occluded uriniferous tubules, etc. The lesions are usually focal, and small areas of extreme fatty degeneration of the renal epithelium are sometimes conspicuous. In the *primary chronic interstitial nephritis* the most conspicuous lesion is the overgrowth of cicatricial connective tissue (Fig. 3067). This is a replacing fibrosis—the result of gradual atrophy of the renal parenchyma. The connective-tissue overgrowth is usually more marked in the cortex than in the medulla; in the cortex it is usually focal in character, small areas of the kidney being successively involved, whereas in the medulla it is more diffuse. In all stages this newly formed connective tissue contains a considerable number of small round cells, but as the process advances it becomes markedly fibrillar and frequently encircles the capsules of Bowman in a lamellated fashion and spreads to the adjacent intertubular tissue. In some places granules of blood pigment the remains of previous hemorrhages may be apparent. The glomeruli reveal all grades of alteration from moderate fibrosis to complete obliteration and hyaline metamorphosis. The less marked changes consist of hyaline degeneration of the vascular tuft, proliferation of the epithelial and connective-tissue cells of the Malpighian bodies, and the formation of new connective tissue. These progress until the Malpighian body is represented by a functionless, roundish hyaline mass. The tubular changes consist of more or less atrophy of the epithelium. This varies in degree and is usually most marked where the connective-tissue new formation and cicatrization are most marked. In some places the

epithelium may have entirely disappeared. At the surface of the kidney in the granular projections hyaline and fatty degeneration of the epithelial cells, dilatation of the uriniferous tubules due to connective-tissue constriction and occlusion by tube casts, desquamated epithelium, cell detritus, etc., may be apparent. The cysts already mentioned result from occlusion of the tubules and the Malpighian bodies. The arteries reveal varying degrees of sclerosis—usually advanced sclerosis. Endarteritis frequently progresses to complete occlusion of the lumen. The changes in the adventitia are often very marked, leading to more or less atrophy of the muscularis, and spreading to the adjacent intertubular tissue. In *arterio-sclerotic nephritis* the changes in the blood-vessels are the primary event, the changes in the renal parenchyma being the result of defective nutritive supply. The changes in the blood-vessels, therefore, are most conspicuous, and the areas of atrophy may be seen to bear a direct relationship to the blood-vessel alterations. In many respects, however, the arterio-sclerotic kidney is scarcely to be distinguished from the kidney of primary chronic interstitial nephritis; indeed, some observers decline to make any distinction between the two.

In addition to changes in the kidneys characteristic changes occur in the heart and in the blood-vessels: in the heart, hypertrophy especially of the left ventricle, and in the blood-vessels, sclerosis. Chronic diffuse indurative nephritis thus is not merely a local disease affecting the kidneys; in most cases it is a widespread disease affecting the kidneys and the entire vascular apparatus—the heart and the arteries especially, but sometimes also the veins. In the majority of cases doubtless it commences in the kidneys, but it speedily implicates the heart and the blood-vessels; in some cases analogous lesions have been found in structures as remote as the liver, etc. In some cases it is likely that the lesions commence simultaneously in the kidneys and the cardio-vascular apparatus. A conspicuous feature of many cases is the development of miliary aneurisms that involve especially the arteries of the brain, and that, by rupturing, frequently lead to a fatal termination.

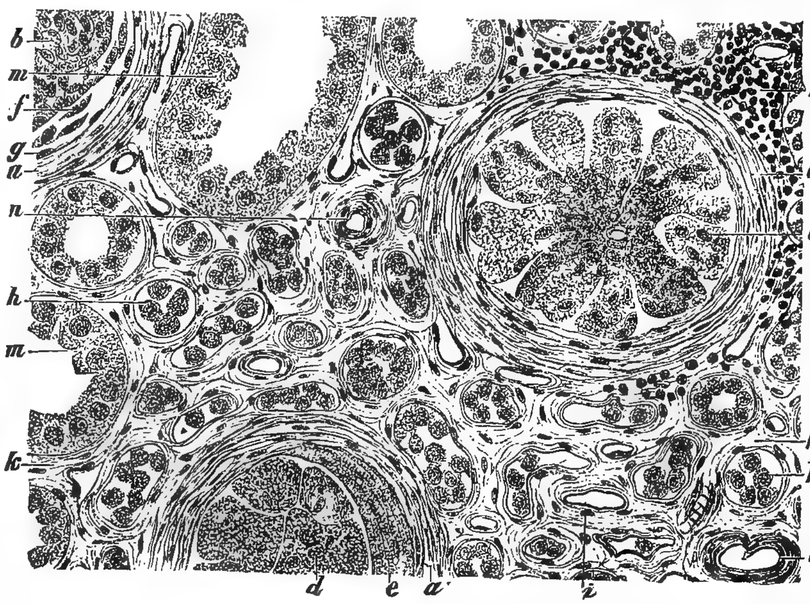

FIG. 3067.—Chronic Diffuse Indurative Nephritis with Atrophy of the Renal Tissue. *a*, Thickened and fibrous Bowman's capsule; *b*, normal glomerular vessels; *c*, glomerulus with partly impermeable and homogeneous vascular loops and almost entirely devoid of epithelium; *d*, obliterated glomerulus; *e*, homogeneous coagulation mass with nuclei, exudate, and epithelium; *f*, desquamated glomerular epithelium; *g*, capsular epithelium; *h*, collapsed urinary tubule with atrophic epithelium; *i*, collapsed tubule devoid of epithelium; *k*, hyperplastic connective-tissue stroma; *l*, collection of small round cells; *m*, normal, but somewhat dilated, urinary tubule; *n*, afferent vessel; *o*, vein. × 250. (Ziegler.)

Symptoms.—It is sometimes impossible to recognize *secondary chronic interstitial nephritis* clinically—to differentiate between the large white kidney and the small white kidney. Presumptive evidence of secondary contraction of the kidney, however, is afforded by long duration of the disease (more than a year); lessening in the amount of dropsy; lessening in the amount of albumin in the urine, increase in the daily quantity of urine and decrease in the specific gravity; the presence of hypertrophy of the heart, accentuation of the aortic second sound, and increase in the arterial tension,—in a word, by the advent of symptoms characteristic of primary chronic interstitial nephritis. In many cases, without a knowledge of the previous history of the patient it is impossible to make a differential diagnosis between the secondary and the primary form of contraction of the kidney.

As might be expected from a knowledge of the nature of the process, the symptoms of *primary chronic interstitial nephritis* develop as insidiously as do the pathological lesions in the kidney. The disease may exist for years entirely devoid of symptoms. Indeed, in the majority of cases the early stages of the affection are altogether overlooked, unless they be discovered accidentally by the routine examination of the urine, as, for instance, for life insurance, or for patients ill with other diseases. When finally, after a number of years, the disease does produce obtrusive symptoms, these are usually of such a nature that they are likely, for a time at least, to be attributed to disorder of some organ other than the kidney. Thus, while the patient may present himself to his physician with the idea that he is suffering with diabetes on account of the large amount of urine that he voids, he is just as likely to complain of dimness of vision the consequence of albuminuric neuro-retinitis; or of one of the many manifestations of chronic uræmia, such as dyspnœa or asthma; or of gastro-intestinal derangements, such as gastric catarrh, gastric hemorrhage, or diarrhœa; or of headache, hemicrania, tinnitus aurium, or vertigo; of neurasthenia, pains in the muscles or joints, or eczema; of palpitation of the heart and precordial distress; or, the patient in apparent good health, may suddenly develop a severe and even fatal attack of cardiac failure, or he may pass into uræmic coma or convulsions, or he may suffer an apoplexy and die. The initial symptoms of the disease, therefore, are extremely variable.

In whatever manner the disease manifests itself the diagnosis depends upon the results of an examination of the urine and of the cardio-vascular system. The urine is increased in amount—1,800 c.c. to 4,000 c.c. daily—whence the common complaint of frequent micturition and sometimes of increased thirst; it is acid in reaction, pale in color, of low specific gravity (1.002–1.015). It contains a slight amount of albumin; usually only a trace, and at times no albumin at all. Albumin may be absent for days and even weeks at a time; it may be missed in the early morning urine and be present in that voided later in the day; and it may be present only after exercise, emotional and other excitement, or after eating, especially after eating proteids. The urine deposits a

slight flocculent sediment that contains a few, sometimes a very few (often very narrow) hyaline and pale granular casts, and a few epithelial cells, mostly from the bladder. In many specimens of the urine the casts are so few that it is only after centrifugalization that several very pale hyaline casts may be detected. In some cases a few erythrocytes may be found. The solids of the urine are usually diminished.

The lesions of the cardio-vascular system characteristic of chronic nephritis consist of hypertrophy of the heart, especially of the left ventricle, and of increased arterial tension. The hypertrophy of the heart is sometimes obscured by coexisting emphysema of the lungs, but usually it may be recognized by the increased force and displacement downward and outward of the apex beat, extension of the cardiac dulness downward and to the left, and accentuation of the aortic second sound. Increased arterial tension, which may be expected from the beginning of the disease, is one of the most valuable signs of chronic indurative nephritis. The pulse of high tension is quite characteristic—it is hard and resisting to the palpating fingers, it remains persistently full between the heart beats (this being the important feature of the pulse), and it requires considerable pressure with the fingers completely to arrest the pulsations. The sphygmographic tracings are also quite characteristic. While this hypertrophy of the heart and increased arterial tension may be found in all forms of Bright's disease (but not in all cases), in none of the forms do they so dominate the clinical picture as they do in the primarily contracted kidney—primary chronic interstitial nephritis. They may be expected from the time of the onset of the contraction or atrophy of the kidney, be this of the primary or of the secondary variety. Thus they develop early in the primary form, but they may be (but usually are not) much delayed in the secondary form. They may develop also in the chronic diffuse non-indurative nephritis, and they (more especially the increased arterial tension) have been observed in a considerable number of cases of acute nephritis, more especially in the acute nephritis following infections, such as scarlet fever, etc. In a few chronic cases they are not observed. Their absence may be due to faulty nutrition—the heart not being sufficiently nourished to enable it to hypertrophy; to sclerosis of the coronary arteries; to the faithful performance by the skin and the intestine of their vicarious action whereby they remove those excrementitious products ordinarily eliminated by the kidneys, etc.

The existence of these cardio-vascular changes, as also the kidney lesions, may for a long time remain entirely unknown to the patient and be absolutely unsuspected by the physician. Whatever be their exact mode of development (and many theories have been advanced, but as yet the correctness of none has been conclusively demonstrated), it is certain that they arise in response to excessive demands on the part of the general economy. So long as the heart continues to perform its increased work well no symptoms occur. Should, however, the increased quantity of urine or the development of slight swelling about the eyes or the ankles attract the patient's attention; or should he suffer from epistaxis (usually of serious moment), or from dimness of vision (due to neuro-retinitis), or from severe muscular cramps in the calves of the legs (which are quite common), or from any of the symptoms of chronic uræmia, inquiry on the part of the physician may elicit the information that for months, possibly years, excitement and exertion have been provocative of breathlessness and palpitation of the heart; but having an obvious cause they were regarded as of no particular significance. As the disease advances, however, the nutrition of the heart no longer keeps pace with its enlargement, degenerations ensue, and evidences of embarrassed circulation result. It is now that symptoms referable to the cardio-vascular system dominate the clinical picture. To the hypertrophy of the heart, if it were simple, there supervenes dilatation, and to disease of the left ventricle is added disease of the right. There result cardiac asthma, congestion and œdema of the lungs, bronchitis, gastro-intestinal disturbances, generalized œdema and effusions within the serous cavities, and alterations in the urine. The urine lessens considerably in amount, and it becomes of high color and increased specific gravity; albumin increases in amount and casts become more numerous; dark granular, epithelial, and even blood casts and free erythrocytes may be encountered. The symptoms referable to the heart and lungs, at first transitory and nocturnal, become permanent, the other symptoms mentioned are added, and if relief is not afforded, death ensues with cardiac failure or uræmia or both dominating the final scene. Toward the end of life, concurrently with the cardiac failure, the pulse, which had been of high tension, may become of lessened tension; the second aortic sound becomes less accentuated; with embarrassment of the right heart the second pulmonary sound becomes accentuated; signs of dilatation, and gallop rhythm, always of serious moment, supervene.

In some cases the first suggestive symptom may be œdema of the lungs or of the larynx. The dyspnœa due to one or both of these may be augmented by hydrothorax; Cheyne-Stokes breathing may ensue, and in coma the patient may die. In other cases, the first suggestive symptom may be violent headache—due either to uræmia, cerebral congestion, or cerebral anæmia. The headaches are occasionally relieved by epistaxis, which is sometimes frequent and sometimes severe. Drowsiness and other of the nervous manifestations of chronic uræmia may be associated with the headaches, and frequently presage the onset of severe, acute, and even fatal uræmia. In some cases psychoses are prominent. In other cases neuralgias, or hemorrhages into the brain substance or into the meninges may occur. Hemorrhages into other structures, especially the stomach, intestine, skin, conjunctiva, lungs, etc., have been observed. Severe and uncontrollable vomiting and severe and exhausting diarrhœa are not uncommon. In other cases the disease is manifest by intolerable itching, formication, numbness of the extremities; in still other cases, by urticaria. In the late stages more or less widespread erythematous, or bullous, or desquamative skin lesions may occur. The most important symptom on the part of the special senses—neuro-retinitis—has already been mentioned. At times tinnitus aurium possibly associated with dizziness occurs; less frequently deafness or diplopia.

Diagnosis.—So long as cardiac compensation is maintained, the diagnosis of chronic indurative nephritis is evident from the results of an inquiry into the antecedents of the patient, the special etiological factors in the case, the course of the disease, the different clinical manifestations, and an examination of the urine and of the cardio-vascular apparatus. Indeed, a diagnosis based upon increased arterial tension, accentuated aortic second sound, and the physical signs of hypertrophy of the heart will rarely be wrong. The diagnostic importance of these cardio-vascular alterations cannot be overestimated. They are among the earliest clinical manifestations of the disease, and they may be detected even in the absence of positive signs of kidney disease on the part of the urine. Such is their double import, that, in the event of suspicion of chronic indurative nephritis, they should be diligently sought, and in the event of their accidental detection in the course of the routine examination of a patient, the presence of an unsuspected or latent chronic indurative nephritis must be persistently borne in mind until these cardio-vascular signs are otherwise adequately accounted for. It is usually a matter of extreme difficulty to distinguish clinically between primary chronic interstitial nephritis and the arteriosclerotic kidney; in some cases it is impossible; in most cases it is unnecessary. Usually the arteriosclerotic kidney exists for a long time without albuminuria, or with but the slightest trace of albumin in the urine. The disease may be suspected in elderly persons, with hypertrophy of the heart, increased arterial tension, and marked atheroma of the superficial arteries. Occurring as a manifestation of senility, it is usually of relative unimportance as contrasted

Kidneys.

with the coexisting emphysema, dementia, marasmus, etc. When the heart begins to fail in chronic interstitial nephritis, diagnostic difficulties arise. The clinical picture in these cases much resembles that of a disorder primarily cardiac and secondarily renal. The presence of murmurs is not conclusive evidence, since they may be due to dilatation as well as to valvular disease. Diastolic murmurs, however, suggest a primary cardiac disorder, whereas albuminuric neuro-retinitis suggests a primary renal disorder. In some cases the diagnosis, for a time at least, is impossible; in other cases it may be made by a careful analysis and balancing of all the features of the case, by a knowledge of the past history of the patient, and by the results of administering digitalis and other heart tonics. Following the administration of digitalis, should the patient improve materially, should the urine increase in amount, and should albumin and casts finally disappear from the urine, the condition has been definitely determined to have been primarily cardiac with secondary renal congestion. If, however, with improvement in the condition of the heart, albumin and casts do not disappear from the urine, we may be confident of the existence of nephritis, a conviction that may be confirmed by examining the cardio-vascular apparatus now that compensation has been restored. It is scarcely likely that chronic indurative nephritis will be confounded with the so-called functional, physiological, cyclic, intermittent, paroxysmal, or adolescent albuminuria.

Course and Prognosis.—Chronic diffuse indurative nephritis may run a course entirely latent and lead to a sudden termination of life through the advent of acute uræmia, apoplexy, etc. In general the prognosis depends in large measure upon the condition of the cardio-vascular apparatus. In the early stages of the disease, in the stage when the disease may be discovered accidentally before there are any obtrusive evidences of it, the prognosis is fair with regard to life expectancy. The patient, however, should be warned of his affliction and advised to lead a hygienic, moral, and abstemious life. In these circumstances he may live ten, even twenty or more years; and it is not unlikely that the removal of the cause of the disease in the individual case may result in a standstill of the lesions in the kidneys and in the cardio-vascular apparatus. The dangers most to be apprehended are cardiac failure, rupture of the smaller arteries, especially those of the brain, and uræmia. In the later stages of the disease the factors that most influence prognosis are the condition of the cardio-vascular system, the quantity of urine excreted daily, the manifestations of uræmia, and the presence or absence of secondary infections, particularly those of the serous membranes, lungs, etc. With embarrassment of the circulation the prognosis becomes very bad. Compensation, when it fails, is sometimes never regained; with judicious treatment, however, the patient may be tided over the critical period and live, if careful, for a number of years. It is especially important to watch the quantity of urine excreted daily. Diminution in the quantity of urine often presages the onset of uræmia, which, however, may be averted by timely interference. The importance of the condition of the heart is here again brought into evidence, since failure of the cardiac power results in diminution in the amount of urine. This diminution in the amount of urine is especially a cause for concern if it be associated with headache, and both then demand immediate attention.

Treatment.—From the natural history of the disease we derive our indications for treatment, which are: (1) As far as possible, to remove the etiological factor in the individual case; (2) to prevent the accumulation of waste metabolic products in the system; (3) to maintain the integrity of the cardio-vascular apparatus; and (4) to meet the symptomatic indications as they arise. Thus the cardio-vascular manifestations of the disease assume a commanding position not only in the diagnosis and in the prognosis, but also in the treatment. In the early stages of the disease, when the patient may complain only of the passing of large quantities of urine, or of dyspnœa on exertion, etc., or when the physician may accidentally detect increased arterial tension, the nature of the disease should be recognized after a thorough investigation of the urine and of the heart, etc. Appreciating our inability definitely to cure our patient, we should be alert to the dangers that threaten him. He must be cautioned not to expose himself to the inclemencies of the weather; he must avoid all excessive muscular exercise, and if possible all mental worry; he must have his bowels open at least once daily, and in every way he must favor the action of the skin, so that as little work as possible may be thrown upon the diseased kidneys, heart, and blood-vessels. The skin, though a poor substitute for the kidneys, is still capable of performing considerable excretory work, and its action should be facilitated as much as possible—by wearing woollen underclothing and by a daily tepid bath. Hot baths may be given, but not indiscriminately; they are contraindicated if they increase the blood pressure to such a degree as to cause unpleasant throbbings. The action of the bowels should be promoted by a daily saline cathartic or by the use of any one of the well-known saline mineral waters. The diet is of the utmost importance, and probably the duration of life depends as much upon discretion in eating and drinking as upon any other factor. The matter, however, is largely individual. In many cases it is advisable to try an exclusive milk diet for a time. If the patient is obliged to take to bed this is all the more indicated. Milk, however, is most distasteful to many patients who will not submit to an exclusive milk dietary, even if assured that they will do better on it than on any other dietary—which is doubtful. In general it may be said that that diet should be allowed which best promotes a healthy state of body and mind; a diet free from irritative quantities and readily assimilable, a diet in which the nitrogenous elements are relatively reduced, and a diet sufficiently varied to be attractive. Whether or not albuminous food should be allowed must be decided in the individual case. In some cases it is well to withhold it for a time; in other cases moderate amounts may be permitted with good results. Large amounts appear to be injurious to most patients, though this is a subject that is still debated. However, it is quite certain that in many cases the exclusion of proteids from the dietary is not followed by good results. A wise rule is to permit some of the lean and easily digested meats to be partaken of once a day. Eggs are suitable and will be found of good service when taken raw—beaten up in milk. Tea and coffee in moderation may be permitted. In many cases alcoholic beverages must be prohibited; in other cases a little of the lighter wines may be allowed. In many cases the foregoing with an occasional mercurial purge, followed by a saline, for its depletive effect and its tendency to lower blood pressure, will suffice to produce amelioration of the symptoms, and possibly arrest of the lesions. If it accomplishes this, no other medicines should be given for the time being.

When the circulation becomes embarrassed medication is called for—the most serviceable remedies being nitroglycerin and caffeine. Nitroglycerin lowers the arterial tension and enables the heart still capable of performing its work to do so unhampered by excessive resistance in the arterial tree; it is said also to favor reduction in the amount of albumin excreted, but this action is doubtful and certainly immaterial. One minim of the one-per-cent. solution, or a tablet containing gr. $\frac{1}{100}$ of the nitroglycerin, should be given three or four times daily. This dose may be increased until the desired result is obtained. It is not necessary that the drug be given to the extent of producing unpleasant symptoms; sufficient reduction in the arterial tension is usually produced without this. Nor is great reduction in the arterial tension desirable; indeed, it is directly contraindicated, since a reduction of the tension even to that of the normal is fraught with danger of serous effusions, and of uræmia (on account of reduction in the amount of urine excreted). The nitroglycerin should be given for from four to six weeks and then discontinued for a week or ten days, unless the condition of the patient should render an earlier

return to its use necessary. In some cases the nitrite of potassium or of sodium may be substituted for the nitroglycerin, but they are less efficacious. During recent years erythrol tetranitrate has been employed with good results. Inasmuch as the nitrites interfere somewhat with the oxygenating powers of the blood their continuous administration should not be persisted in too long. The caffeine is best given in three-grain doses, and generally in conjunction with the nitroglycerin. The only contraindication to its use is an insomnia that it sometimes provokes. Iodide of potassium or of sodium is still advocated in the treatment of this disease, and in some cases good results appear to attend its prolonged use. It should be given in small doses, three to five grains three times daily, unless there be a clear history of syphilitic infection, or marked arterio-sclerosis. It is difficult, however, to estimate the amount of good that with justice may be attributed to its use. The same may be said of small doses of mercuric bichloride and of the chloride of gold and sodium. At all events their use is unattended by harm, and they may serve to retard the progress of the renal and cardio-vascular lesions. In the absence of serious cardiac debility, cardiac stimulants, such as digitalis and strophanthus, should not be given. Nor is the routine administration of iron to be countenanced. Anæmia is rarely marked, and any virtues that iron may possess are outweighed by certain ill effects, such as its tendency to constipate, to produce headaches, etc. However, should anæmia become marked, iron may be given in small doses. Quinine, strychnine, and arsenic are often of service in this stage of the disease, as well as earlier. Quite recently Edebohls and others have attempted the cure of chronic nephritis by stripping the capsule from the kidneys—with results as yet problematical.

When marked cardiac debility and manifest failure of compensation develop (generalized œdema, effusions in the several serous cavities, diminution in the amount of urine, increase in the amount of albumin, etc.), the time for administering digitalis and other cardiac stimulants has arrived. In general, the treatment of this stage of the disease does not differ from that already laid down in connection with acute and chronic non-indurative nephritis, and from that commonly practised in cases of lack of cardiac compensation. Impending uræmia, manifest by headache, restlessness, foul breath, coated tongue, vertigo, etc., may be warded off by nitroglycerin and caffeine, saline cathartics, alkaline diuretics, large amounts of water, hydrotherapeutic measures, and restriction of the diet to milk. In some cases digitalis is urgently called for. The treatment of acute uræmia developing in the course of chronic indurative nephritis does not differ from that already mentioned.

Aloysius O. J. Kelly.

KIDNEYS, DISEASES OF: PARASITES.—In the United States, renal parasites are very rare. Those which are most often observed are: 1, Echinococcus; 2, strongylus gigas; 3, pentastomum denticulatum; 4, distoma hæmatobium; 5, ascaris lumbricoides; 6, actinomycosis.

1. Echinococcus.—This is the most common of the renal parasites, but it is a rare affection. If we add together the figures of Davaine, Neisser, Finsen, and Thomas, we have 2,111 cases of hydatid disease of all parts and organs, in 115 of which the kidney was the seat of the disease—a percentage of 5.44. The actual frequency is probably even lower than this. Hydatids occur more frequently in the kidney than in any other organ of the body, except the liver (most frequent of all) and the lungs. The two sexes seem to be about equally affected. It occurs about twice as frequently in the left kidney as in the right, for which no satisfactory explanation has been offered. The cysts may occupy one or both kidneys. Any part of the kidney may be invaded by the cyst or cysts, which may lie just beneath the capsule or be buried deep in the substance of the organ. The remaining kidney tissue usually continues healthy until the pressure of the cyst becomes injurious. The large cysts often contain daughter cysts. The cysts may remain small in size, or they may attain immense proportions.

Symptoms.—These are very unsatisfactory, and are variously described. The trouble develops insidiously and slowly, is usually painless, and produces no changes in the urine until late in the disease. A palpable tumor takes months or years for its growth, and is usually the first symptom which is appreciable. The tumor is rounded, tense, elastic, not tender, and may have rounded nodules upon its surface. There may be fluctuation and "hydatid fremitus." The cysts may develop rapidly and produce painful sensations from pressure. Rarely hæmaturia may be produced. Some of the cysts may rupture into the pelvis of the kidney, causing the echinococci or their hooklets to appear in the urine, which will at once establish the diagnosis. The passage of the echinococci may produce miniature renal colic, similar to those symptoms caused by the passage of renal gravel or a small calculus. Very often the cysts set up a pyelitis, with pyuria and hæmaturia. The cysts may become infected and rupture externally, producing a perirenal abscess. The hydatid tumor may push upward, perforate the diaphragm, and open into the pleura or bronchi, in which case the echinococci will be coughed up and the expectoration will have a urinous odor. The cyst may rupture into the general peritoneal cavity, or into a hollow organ, *e.g.*, stomach, intestine, etc.

The *diagnosis* is made by considering (Morris):

1. The residence, habits, and calling of the individual in reference to association with dogs. 2. The slow, silent, insidious growth of a tumor. 3. The absence of pain, of fever, of general constitutional disturbances, and of any change in the composition, or any variation in the quantity of the urine. 4. The uniformly smooth, globular outline of the tumor, with fluctuation and hydatid fremitus. 5. The renal connection of the tumor and the lack of ordinary respiratory movements. 6. The possible discharge of hydatids per urethram, by the mouth, or by the anus. 7. Attacks of renal colic caused by, and associated with, the discharge of hydatids by urethra, producing diminution or subsidence of the flank tumor.

Treatment.—Aspiration is dangerous and should not be employed. The same remark applies to the injection of substances into the cysts. The only proper treatment is to cut down upon it by the lumbar route, tap it, removing the fluid by aspiration, and then to incise the cyst wall. As much as possible of the wall should be removed, and the edges of the cavity ought then to be sewn into the lumbar wound. The cavity is then packed and allowed to heal by granulation. Nephrectomy is allowable only when the whole kidney is involved in the cysts. In certain cases it may be possible to excise the whole cyst, in which case the raw surfaces of the kidney may be brought together by sutures. This expedites recovery.

2. Strongylus Gigas.—This parasite is very rare in man, but common in the lower animals. It bears a great resemblance to a large earth-worm but differs from the ascaris lumbricoides in its reddish color, and by its having six papillæ around the mouth, the ascaris having only three. It is found in the renal pelvis, producing great irritation, with pain, hæmaturia, pyrexia, and strangury. The pain is somewhat similar to, though milder than, renal colic. It is not known how the worm reaches the kidney. Incision into the pelvis of the kidney, and the removal of the worm is the only treatment.

3. Pentastomum Denticulatum is a pathological curiosity which has been found once or twice in man, but which has no clinical interest. It is a parasite belonging to the order of "mites," whose natural habitat is the nasal cavity of the dog.

4. Distoma Hæmatobium.—In temperate climates this is rather a pathological than a clinical verity, although it is very common in Egypt and Southern Africa. The embryos enter the alimentary canal through the medium of drinking-water, whence they make their way to the kidneys. They may block the ureter and cause hydro-

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nephrosis. Their entrance into the bladder may cause considerable irritation. The only certain means of diagnosis is the discharge of ova in the urine. No treatment can be adopted which will have any influence on the parasite.

5. ASCARIS LUMBRICOIDES (the common round-worm of the intestinal canal) has sometimes found its way into the renal pelvis—just how, it is difficult to explain. This worm has been mistaken for the strongylus gigas, but this latter has invariably a deep red color, which will differentiate it from the former.

6. Secondary actinomycosis of the kidney has been described several times. Israel has published the first case of primary actinomycosis, diagnosed in life, and successfully operated upon. For a further description of this case, I refer to Israel's work.

Clarence Arthur McWilliams.

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KIDNEYS, DISEASES OF: SYPHILIS. See *Syphilis.*

KIDNEYS, DISEASES OF: TUBERCULOSIS.—Renal tuberculosis occurs under two distinct forms, with one of which—the dead-room manifestation of a general disseminated disease—we have nothing to do except from a statistical standpoint. In these cases both kidneys are almost invariably affected and the diagnosis of renal involvement is not made during life, or, if it may be, it calls for no attention in the face of the more formidable menace to existence from the coexisting implication of the pulmonary, meningeal, and peritoneal structures.

If we permitted ourselves to be guided by such necropsy records it would be idle to expect to find among the living any cases of purely unilateral renal tuberculosis in which our therapeutic resources could be of benefit. The writer's morgue investigations in all forms of renal tuberculosis show a post-mortem percentage of 81, in which both kidneys were tuberculous, and 19 in which but one organ was affected; whereas his clinical material, in which urinary differentiations were made by ureteral catheterization, has given 33 per cent. of double and 66 per cent. of single renal involvement. It is needless to say that all of these cases belonged to the class in which more or less chronic and more or less localized manifestations of tuberculosis prevailed, and in which there were almost always symptoms referable to the urinary or genital organs.

From February 1st, 1893, to March 28th, 1902, 1,427 autopsies were made in the Presbyterian Hospital of New York City: 869, or 60 + per cent., were of males; 558, or 39 + per cent., were of females. Of this number 258 bodies, or 18 per cent., showed some tuberculous lesion somewhere in the body; 169, or 65 per cent., of these were in males, 89, or 35 per cent., in females. Of the 258 tuberculous bodies 48, or 18.5 per cent., showed renal involvement.

Age.	Kidney.	Spleen.	Liver.	Adrenals.	Total.
1 to 5 years	10	16	10	1	37
5 to 10 "	3	3	3	..	9
10 to 20 "	3	3	3	..	9
20 to 30 "	10	4	5	2	21
30 to 40 "	13	4	7	2	26
40 to 50 "	2	1	2	2	7
50 to 60 "	4	2	1	1	8
60 to 70 "	1	..	1	..	2
70 to 80 "	2	..	..	..	2
	48	33	32	8	121

Of the 48 renal cases 32, or 66 per cent., were in males, while 16, or 33 per cent., were in females. Of the 48 renal cases, 39, or 81 per cent., had double infection, while 9, or 19 per cent., had single infection. Of these 9 cases, the right kidney was involved in 5, the left in 4. None of the 48 renal cases failed to show some pulmonary tuberculous lesion. No instances of healed renal lesion were met with, while the records cite 5 cases of healed pulmonary processes.

Cases of acute miliary tuberculosis were much the most common in infancy, and in such the spleen and liver were affected at least as often as the kidneys. The periods between the third and fourth decades were the next most likely ones for tuberculous infection, although here many of the cases were of the acute general variety. The more chronic and more localized forms were, however, strikingly in evidence, and the prevalence of renal tuberculosis over that of the spleen and liver was noted. In respect to individuals at this age, both morgue and clinical records agree in showing that here are mainly to be found the victims of a chronic unilateral renal tuberculosis, which is amenable to surgery.

An attempt was made to collect the number of cases of renal tuberculosis received in the hospital during this same ten-year period, but many difficulties rendered it impossible to make more than an approximate estimate; doubtless quite a number must have eluded diagnosis, and, when no autopsy occurred, they escaped record. Most of the 48 autopsy cases had been unrecognized previously. If these are added to the 34 diagnosed as renal tuberculosis there were in all 81 cases, since one case is common to both counts.

Of the 34 cases diagnosed as bilateral or unilateral disease, 14 of the patients in the latter class consented to the proposed nephrectomy, and of this number 13 recovered, an operative mortality of 7.1 per cent. The one death occurred in a man, twenty-five years of age, at the end of six months, while the patient was still in hospital, and was not due to the operation but to extension of previously existing chronic pulmonary processes and a final acute miliary distribution in these same organs. At autopsy a broken-down tuberculous nodule was also found in the remaining kidney.

A second death occurred in a lad of sixteen years, due to tuberculous meningitis, a little more than six months after operation and five after he had left the hospital. This patient was at the point of death when operated upon, and, although he gained thirty pounds shortly afterward, other foci of the disease had already been recognized before the emergency operation, and it was predicted that a return to his former unhygienic home conditions would result in an early and fatal recurrence. The remaining twelve patients are, so far as can be learned, in a fair state of health at this time. The fourteen patients were, with the exception just mentioned, between twenty and forty years of age.

Etiology.—Although instances of primary unilateral renal tuberculosis probably exist, we must not think that surgical measures of relief are to be reserved for these rare cases alone. Most of the patients supposed to belong in this category are certainly such as have had an insignificant dormant focus elsewhere, and from which bacilli have gained access to the blood and been planted successfully in one kidney. What the antecedent renal condition is which makes it a favorable soil for this bacillary growth and its subsequent necrotic processes, is not known. If irritation or faulty circulation were a predisposing cause the disease ought to be, more frequently than it is, found associated with cases of calculus or gravel, and of movable kidney. It is a striking exception to find a kidney which is at the same time the seat of lithiasis and tuberculosis, unless the concretion represents a terminal stage of the latter and possibly a natural and conservative effort at cure.

On the other hand, a history of some external lumbar or abdominal injury is not so infrequently to be had from these patients, but whether such was appreciated only because the organ was already the seat of disease and unduly sensitive it is difficult to determine, and this difficulty is increased by the fact that occasional cases of renal tuberculosis are far advanced when they first come to the

notice of even the patient. It is claimed by some recent writers that the parenchyma of the kidneys is insensitive, that pain is experienced only in connection with lesions of a distending nature such as lead to stretching of the capsule or distention of the pelvis. This statement would seem to be negatived by the fact that some considerably sacculated tuberculous kidneys are quite painless. It seems to be essential to the occurrence of a primary tuberculous renal lesion that a bacillus should gain admission to a blood-vessel by a prick or laceration, else that it should be taken up from a mucous or cutaneous surface by a lymph space, advanced until it enters a vein, thence carried to the heart and one of the renal arteries, an arteriole of which probably presents it to a glomerulus for elimination. Sherrington's experiments justify the assumption that the tubercle bacillus can pass this filter without any necessary lesion of the excretory membrane.

Durand-Fardel has demonstrated these bacilli within and just outside the vessels of a glomerulus, where they had not yet excited an initial tuberculous process, nor could the microscope detect the slightest evidence of their presence by tissue change or otherwise.

That more often than not the bacilli are carried by the blood to the kidney from some already existing but inappreciable pulmonary lesion is the writer's belief, so that although the renal focus becomes an ostensible and major object of offence it is not really the primary one. If the kidney is successfully removed the original focus elsewhere may long afterward again serve as a point of departure of infection for other organs, or may take on acutely destructive processes within itself. These possibilities should not, however, deter the surgeon from advising the earliest possible nephrectomy for purely unilateral disease.

Two other modes of renal infection are recognized. The so-called ascending, in which extension by continuity of the disease from bladder to kidney takes place (Plate XXXIX.). Here the lymphatic spaces and channels of the ureter are presumably the agents in conveying the bacilli. When this occurs the bladder may have had its original infection from a lesion of the prostate or seminal vesicles, from a descending tuberculosis from the opposite kidney, from an implantation made by an instrument passed through the urethra, or from a focus initiated by blood bacilli transported to the mucosa. This last cause may produce a lesion in the ureter from which the disease can be spread both upward and downward.

When tuberculosis reaches the kidney from the ureter it generally presents a picture of necrosis extending peripherally in contradistinction to the processes which characterize a blood-implanted tuberculosis in which the cortical zone of the kidney—that part containing the great majority of the glomeruli—is the principal part to suffer the early inroads of destruction; although the pelvis and parts of the ureter may be affected with tubercles planted from the cortical lesion.

The third mode of infection is by indirect extension through the renal capsule from a tuberculous disease of some contiguous or remote organ. Such occurrences are very rare. Although it is not infrequent to find advanced tuberculosis of the adrenals at autopsy, the writer has seen no cases cited of a contact infection of the kidney, whereas, in cases of new growth of the adrenal body, invasion of the kidney is not rare.

The renal capsule seems to exert a sufficient protection against tuberculous contagion of its parenchyma, but through the pelvis a burrowing vertebral abscess occasionally makes a successful breach, and very rarely a tuberculosis may by invasion of the ureter extend from the peritoneum to the kidney. It is probable that eighty per cent. of the cases of renal tuberculosis are of hæmatogenous origin.

The susceptibility of the kidney to infection by pathogenic germs carried to it by the blood has been clearly demonstrated, whereas the potency of the lymphatic channels for rapid and wide germ dissemination is not so well established; yet in the distribution of bacteria by the continuity of their pathological processes for limited distances and by comparatively slower progress, the efficacy of the lymphatics is perfectly appreciated. That this is the mode of dissemination in an ascending renal tuberculosis I am inclined to believe, and I have also no doubt that it represents the mode of extension of the disease to the other parts of any already infected organ or group of organs.

It was a good while ago ascertained that the secretions and tissues of the healthy body do not contain bacteria, and it is now equally well recognized that when bacteria have gained an entrance to the body they may appear in the secreta. Particularly is this true when the germs are such as are known to be capable of exciting lesions in the organs affording the secretion. Thus, in Wyssowkowitsch's experiments in seventeen animals subjected to intravenous injection of different micro-organisms pathogenic to the kidneys, the germs were found in the urine thirteen times.

The non-pathogenic germs, on the other hand, wholly disappear from the circulation after a while without having appeared in the secreta.

As long ago as 1882 Cohnheim maintained that by renal excretion the human organism possessed the means of ridding itself of both dissolved and organized poisons. Among the latter he included tubercle bacilli, and he held that they could be transferred from a pulmonary source by the blood to the urine and so enter the bladder, there to establish a tuberculosis without injuring or infecting the kidney during their passage.

Von Kahlden professes to have observed kidneys through which the bacilli have filtered, and which organs did not present the slightest alteration caused by the transit of the bacilli. The impossibility, however, of a thorough examination of the entire glandular tissue of a kidney must be apparent.

The investigations of Cavazzani and Wyssowkowitsch led them to conclude that this passage of micro-organisms through the renal membrane could not occur prior to some lesion of the renal epithelium, and that such a lesion was associated with the escape of blood.

From his own experiments Sherrington decided that because proteids are not always discoverable in the urine, it is not necessary to insist upon the conclusions of Wyssowkowitsch and others, according to which noxious bacteria escape in the secreta only when the blood itself containing them escapes. And yet he admits that his deductions are equally opposed to the extreme views of Cohnheim and others, who assert that the transit of bacteria across the renal membrane occurs while it is still normal in condition.

"This membrane," Sherrington says, "is rather to be regarded as then exhibiting in a minor degree the pathological change which, when increased, will render it pervious to the same extent that the capillary wall becomes pervious in an area of inflammation." This opinion he believes to receive support from the fact that the injected germs are not immediately found in the secreta, but only subsequently, after the poisons produced by the infection have had time to act upon the membrane and render it pervious.

Sherrington adds: "Among the species observed to escape through the membrane, even in the absence of escape of blood, are some that are not motile; this suggests that in their transit across the secreting membrane the bacteria themselves are passively conveyed, that the transit is less an active migration than a passive transference."

It is, then, a pertinent question whether the victims of more or less general tuberculosis can present tubercle bacilli in their urine and yet not have tuberculosis of the urinary tract. One of Sherrington's experiments, already referred to, would lead us to believe that this is possible.

I saw some years ago a case in which this hypothesis could not but be considered. I had resected the tuberculous left knee of a man, A. O., twenty-eight years old, who since the age of ten years had given evidence at

EXPLANATION OF
PLATE XXXVIII.

EXPLANATION OF PLATE XXXVIII.

FIG. 1.—Chronic Renal Tuberculosis. At the lower pole of the kidney is seen a calcareous concretion surrounded by a thick fibrous capsule. In the middle zone there is a caseous mass which is walled off from the surrounding tissues in a similar manner—nature's effort to effect a cure. At various places in the cortex are miliary and larger tubercles of later date. (Dr. Charles N. Dowd's case of nephrectomy.)

FIG. 2.—A Non-tuberculous Kidney which has Undergone Lipomatous Transformation, Secondary to Calculous Disease. The stone is seen in the pelvis. This metamorphosis is similar to that described by some writers as healed renal tuberculosis. (Dr. Robert F. Weir's case of nephrectomy.)

FIG. 3.—Pseudotuberculosis of the Kidney; "Pseudotuberculosis Cladothrichica" of Eppinger. (Dr. George A. Tuttle's case.)

FIG. 4.—Subacute Renal Tuberculosis. The kidney shows on its surface numerous cortical tubercles and one considerable cyst. (Dr. F. Tilden Brown's case of nephrectomy for disease involving one kidney.)

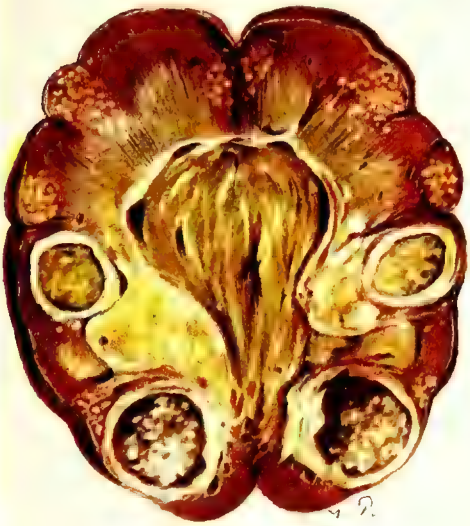


FIG. 1

FIG. 2

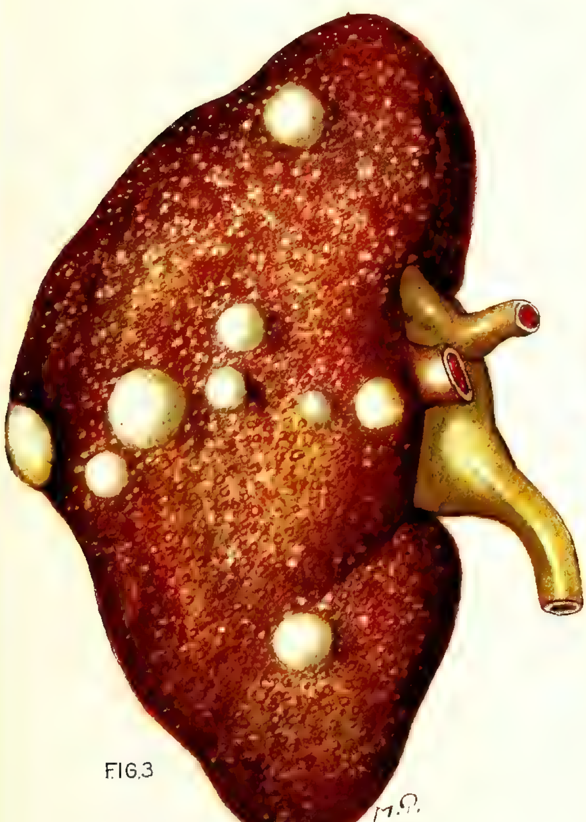


FIG. 3

FIG. 4

POST-MORTEM APPEARANCES IN CHRONIC TUBERCULOSIS AND PSEUDO-TUBERCULOSIS OF THE KIDNEY.

(CASES OF DR. DOWD, DR. WEIR, DR. TUTTLE, AND DR. F. TILDEN BROWN.)

[Only slight reduction in size.]

different times of various regional tuberculoses. Three months later his tuberculous right testicle was removed. Although he had never experienced any urinary symptoms, I examined his urine before the last operation, and found tubercle bacilli in each of four mountings; I then examined him more closely in reference to vesical or renal symptoms, but with negative result. Hence I was led to infer that the bacilli must have come from the urethra, prostate, or seminal vesicles. To test it, some two weeks later the urine was collected by a sterilized catheter, allowing an ounce, for cleansing the eye, to run off uncaught. As before, the urine by gross inspection was quite clear by centrifugal sedimentation; enough pus corpuscles were obtained to make six slim mountings. Tubercle bacilli were found in each; in nearly every instance the bacilli were in the leucocytes. The urine was sterile to culture on the ordinary media. It was acid, of 1.022 specific gravity. There was no albumin, and but an occasional blood cell was found microscopically. The patient did not have to urinate during the night, and he had no frequency of micturition during the day.

This catheter test did not, of necessity, warrant the positive conclusion that the bacilli came from the kidney; but had they come from a vesical lesion, I think some epithelial cells would have been found with the pus cells. After he left the hospital I saw the patient several times, and always found him going about in what he called "good health," having gained about fifteen pounds since the operation. All attempts to discover some subjective evidence of urinary trouble were futile.

Four months later, in May, 1896, he was taken suddenly ill and brought to the medical service of the Presbyterian Hospital, where he died three days later of acute miliary tuberculosis of the lungs. It was of great interest to determine the source of the tubercle bacilli found in his urine two years before. Autopsy afforded this opportunity. In the left kidney were two moderate-sized chronic foci communicating by calyces with the pelvis. The left ureter was much dilated in two places, hyperæmic, and contained a few minute tubercles. There was a single lesion in the right kidney similar to those in the left, but it appeared to have no communication with the pelvis of the organ. The vesical mucous membrane about the left ureteral opening was conspicuous by the size of its blood-vessels only. Both seminal vesicles had old cheesy deposits. The size and shape of that on the right side caused a marked asymmetry of the base of the bladder and ureteral openings (see New York *Medical Journal*, April 3d, 1897). Every portion of both lungs was studded with minute tubercles. The patient's temperature had been almost constant between 104° and 105° F. during the three days that he was in the hospital. The urine appeared normal and showed no albumin. It was not then examined for tubercle bacilli.

Whether this fatal attack of pulmonary tuberculosis was instituted by a fresh infection of more virulent bacilli or by a great and sudden dissemination (by way of the blood channels), throughout the lungs, of the very parasites he had so long nourished elsewhere, must be left to conjecture.

A great proportion of the victims of chronic tuberculous disease of the kidney is to be found among those having a more or less marked family history of tuberculosis. For this reason trifling urinary symptoms should, in such cases, receive the most careful and persistent scrutiny.

The *pathology* of renal tuberculosis does not differ from that of the disease found elsewhere, and its morbid anatomy is mainly dependent upon the mode of invasion, the activity of the disease, the virulence of the bacillus, and the resisting powers of the individual. After deposition, by the blood, of tubercle bacilli in the cortical area of the kidney, the presence of epithelial and giant cells surrounded by and interspersed with lymphoid corpuscles is the typical picture of a commencing miliary granulation. The lesion, microscopic at first, progresses to a stage where it becomes a grayish-white or yellowish tubercle seen and felt on gross inspection. The further development of the single lesion or the coalition of several similar lesions leads by coagulation-necrosis to the cheesy nodule. Augmenting at the expense of the surrounding parenchyma, this finally ruptures into one of the calyces, its contents and subsequent débris then mingling with the excreted urine. More rarely the lesion works toward the capsule, lifting and possibly breaking through it, and instituting there a perinephritic tuberculosis. When a very low grade of activity pertains, the evidences of efforts to stay the progress of such a lesion may rarely be met with in the shape of a dense white-walled limiting membrane encasing either a putty-like substance or a still more advanced metamorphosis of the latter in the shape of a calcareous formation. A beautiful example of this is seen in parts of a tuberculous kidney recently removed by Dr. Dowd (Plate XXXVIII.).

Cystic degeneration of tuberculous origin, independent of ureteral occlusion, is occasionally met with. Tuberculous hydronephrosis is most commonly initiated by ureteral occlusion due to ascending disease, whereas tuberculous pyonephrosis is generally due to occlusion of the ureter by cheesy matter or tissue débris from the already diseased kidney.

Cases of complete arrest of renal tuberculosis are occasionally reported. Madelung describes a condition in which the renal pelvis is invaded by a sclerotic fatty tissue with closure of the ureter and apparent cessation of active inflammation; Michel reports a case in which extreme atrophy of the affected kidney was attended by the formation of an encasing mass of sclerotic fat. A very similar condition is shown by Morris to be at times initiated by a perinephritis, in which the cellular and adipose tissues surrounding the kidney take on this unusual change. And, again, some affection of the kidney itself appears responsible for a later invasion of its parenchyma by fat, probably starting along the vessels at the hilum. In extreme cases this will transform the whole organ into a fatty mass. A rare specimen, in which a calculus encased in the pelvis may have been the initial cause of this lipomatous metamorphosis, is seen in what was once a kidney, removed by Dr. Weir (Plate XXXVIII.); and, from the description given, we presume that it represents the same appearances as were observed in the cases of healed renal tuberculosis described by Madelung, Tuffier, Le Dentu, Newman, and Michel.

Diagnosis.—When a kidney is exposed at operation it is often impossible to say from gross inspection that it is affected with tuberculosis. But this is scarcely necessary, for the diagnosis as to both the nature and the localization of the disease should in every case be made before the patient is brought to the operating table; and consequently we shall not attempt to give a table of differential diagnoses to help distinguish between the appearances of a tuberculous kidney and those of the septic, syphilitic, malarial, carcinomatous, or leprous kidney. Because of its variety and novelty, it may, however, be of interest to give a brief description of a disease which presents cortical and disseminated lesions exactly like those of tuberculosis. Not alone macroscopically but histologically both diseases are characterized by infiltration of the framework surrounding the lesions, by degeneration of the inflammatory exudate going on to necrosis, and by solution of the tissue and exudate.

PSEUDOTUBERCULOSIS.—The illustration—Fig. 2, Plate XXXVIII.—is that of a kidney removed at autopsy from a patient of Dr. G. A. Tuttle, of the Presbyterian Hospital, by whom the specific micro-organism has been cultivated and extensively experimented with. Dr. Tuttle's studies are abbreviated in the following résumé.

A disease which closely resembles tuberculosis in the character and distribution of its lesions, and which, in certain stages at least, presents almost precisely the same appearances as those which are observed in miliary tuberculosis, so that it may easily be mistaken for that disease, was first described by Eppinger in 1891 as "pseudotuberculosis cladothrichica." The micro-organism proved by Eppinger to have caused the disease was reported by him as a cladothrix, although he described a real branching of the threads. It has been found to be a

species of streptothrix, a genus of the family to which belong the tubercle bacillus, the Klebs-Löffler bacillus, and the actinomyces. During the past six years seven similar cases have been reported by different observers, one of them having been diagnosticated during life and the diagnosis confirmed at autopsy. A few other cases have been reported as streptothrix disease, but the proofs have not been convincing.

A case of this disease in which were combined the lesions described by the different observers, occurred in the medical service of the Presbyterian Hospital in the summer of 1898. The patient, a woman thirty-three years of age, gave the history and presented the clinical symptoms of acute lobar pneumonia. The onset was sudden and was marked by a chill with fever, rapid pulse and respiration, pain in the left side and back, and cough. There was a small area of consolidation in the lower part of the upper lobe of the left lung, which increased to four or five inches in extent. Prostration was marked. Great pain in the lumbar region and thighs and intense vesical tenesmus were prominent symptoms in the later stages of the disease. Eight or ten small subcutaneous abscesses appeared on the forearms, abdomen, and thighs, and there were repeated attacks of profuse sweating. Death took place on the fifteenth day of the disease.

The autopsy, nine hours after death, showed a resolving area of pneumonia in the left upper lobe, the appearance of acute miliary tuberculosis in the right lower lobe, and small foci of suppuration scattered throughout both lungs. One small cheesy nodule was found in the right lower lobe. The heart muscle showed several small white infarctions which were becoming softened. Opposite one of these, in the wall of the left ventricle, was a thrombus of fibrin containing foci of pus. The pancreas contained many small abscesses. The liver and spleen were normal. The kidneys were thickly sown with minute white granules, evenly distributed through their substance and showing on the surface. In addition there were several prominent white nodules, one-quarter to one-half inch in diameter, which were found to contain thick, tenacious matter. The mesentery was densely studded with miliary tubercles and tubercles were scattered over the parietal and intestinal peritoneum.

The microscopical examination showed a typical picture of tuberculous inflammation in the lower lobe of the right lung. There were characteristic tubercles composed of epithelial cells and giant cells, some with cheesy degeneration, and some with fibrous tissue in the centre. There were also areas of cicatricial fibrous tissue such as are seen in chronic tuberculosis. No other characteristic tuberculous lesions were found. The kidneys showed little collections of small round cells, some of them with a central area of granular degeneration, but no giant cells were found. Careful searching failed to discover any tubercle bacilli in any of the lesions, even in those of the right lung which appeared most certainly to be tuberculous. Smears from the abscesses and sections of the lungs, heart, and kidneys, stained by Gram's method, showed an abundance of branching threads in the tubercle-like nodules. None, however, could be found in the tubercles with giant cells, these apparently being lesions of longer standing than the small round-celled tubercles.

Cultures from the kidneys showed a pure growth of slender branching threads in light yellow colonies. Growth occurred in the incubator upon all of the common culture media. Spores were formed upon potato. Subcutaneous abscesses developed in rabbits and guinea-pigs at the site of inoculation, but the animals recovered. When the bacilli were placed in the blood stream in rabbits, rapid emaciation and death resulted in from seven to sixteen days, with widespread tubercle-like lesions, always most numerous in the kidneys.

If we compare the appearance of the growths on different culture media and the results of animal experiments with the descriptions of Eppinger's streptothrix, we see that the micro-organisms found in the two cases are closely similar if not identical.

No motility of the bacilli was noted at any stage of growth in Tuttle's case, while Eppinger described a slow movement of the threads. Other observers were not able to confirm this.

The *symptomatology* of renal tuberculosis taken collectively gives a rather complex picture. The symptoms not only vary more or less at different stages, but it has to be remembered that, according as infection has occurred through either of the two main channels of access to the kidney—the arterial and the ureteral—the symptoms, during the early stages at least, will be dissimilar.

In cases of blood infection, when the newly planted tubercles act as excitants to the functional activity of the organ, polyuria is not infrequently noted; but with this exception the early stage may be symptomless until the lesions have advanced to the formation of a palpable tumor, or have reached the stage of eruption into one of the calyces, which often occurs before tumefaction. With this rupture may at once occur in a minor degree some of the symptoms which will have been present from the outset in a case of the ascending ureteral variety; for the victim of the latter will have been undergoing, for a long time prior to ascending access to the kidney, all those distressing vesical and ureteral symptoms to which for the first time a patient with the first form of infection is now exposed through the liberation of tuberculous material by rupture of the hitherto walled-in kidney lesion. Although the writer has never seen a specimen which demonstrated positively this invasion of the kidney by ureteral ascent—the kidney for instance being sound, while yet the ureter showed tubercles spreading upward from a similarly diseased bladder—he has no sufficient reason for denying the possibility of its existence. He has always regarded the right kidney and ureter shown in Plate XXXIX. as an example of this sort, while the totally destroyed organ of the opposite side must have been an antedating infection that originated by way of the blood, since the ureter shows nothing besides a stricture choked with débris.

Sometimes the subjective symptoms are pronounced even in the early stages, there being an acute pain referable to the kidney or upper part of the ureter. When such painful seizures occur as crises, accompanied by nausea and vomiting, the attendant is more apt to suspect renal calculus, gravel, or angled ureter with movable kidney than tuberculosis. In other cases, again, pain is little noticed in the advanced stages of the disease; all that we find is an irritable behavior of the bladder, and too often these vesical symptoms are cited by the physician as evidence that this viscus is the original and only seat of the trouble. A dull aching in the lumbar region is always significant, and when in addition to this a mass corresponding to the kidney can be palpated, the manipulation eliciting pain, the indication for further study is strong. Commonly in the early stage no kidney can be felt, but bimanual pressure will show that the organ is more sensitive than the opposite one.

In quite a proportion of the cases it will be found that the patients give a history of having had, at different stages of the disease, malaise with chilly and febrile manifestations resembling malaria, and of having been treated at various intervals for this disease. A mixture of blood with the urine in sufficient quantity to attract the attention of the patient and be called a hemorrhage is an unusual symptom, which has, however, at times been noted as one of the earliest; but it points with vastly greater probability to the presence of a new growth. On the other hand, a microscopic quantity of blood is among the commonest of the symptoms of renal tuberculosis from the time of rupture of the lesion until the end.

Pyuria, which in varying degrees is a constant symptom after the stage of rupture, is apt to be noted by intelligent individuals, and to the physician it should give immediate warning to look for tubercle bacilli. Especially is this the case when with an acid urine the microscopic mounting, dried and stained only with methylene blue, shows a field containing nothing but pus corpuscles and an occasional blood cell with very few or no epithe-

EXPLANATION OF
PLATE XXXIX.

EXPLANATION OF PLATE XXXIX.

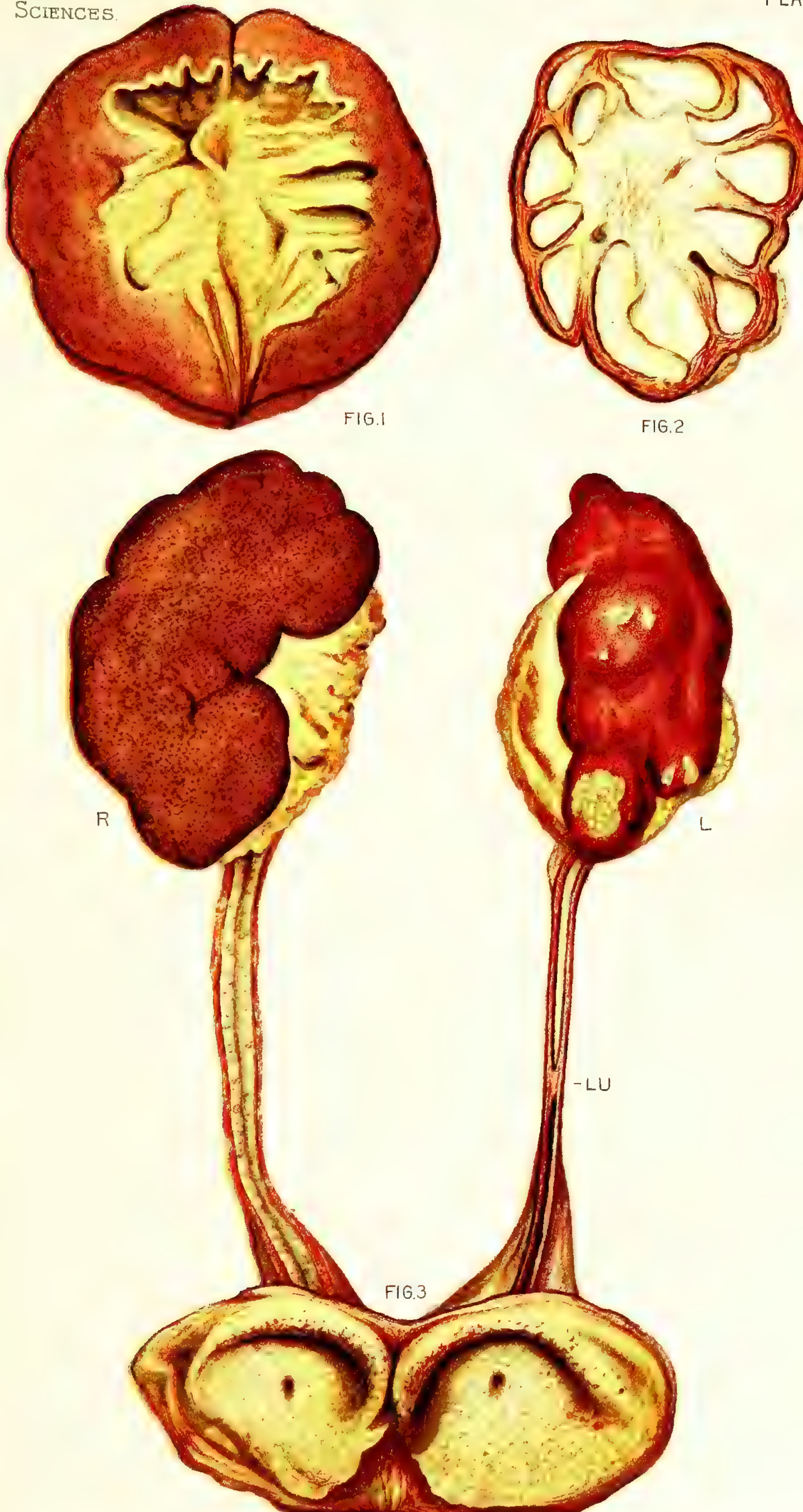
Post-mortem Appearances in a Case of Chronic Diffuse Urinary Tuberculosis. (Patient of Dr. F. Tilden Brown.)

Fig. 1.—Aspect of Right Kidney after Being Laid Open. The changes to be noted are the following: Compensatory hypertrophy and tuberculosis spreading from within; the presence of tubercles in the pelvis, representing presumably a direct extension from those located in the right urefer; and the destruction of one pyramid. Attention is also called to the fact that there are no cortical lesions.

Fig. 2.—Inner Aspect of the Left Kidney. The glandular tissue of this organ has been wholly destroyed and each pyramid replaced by caseous material.

Fig. 3 represents the kidneys, ureters, and bladder (belonging to the same patient) in their natural connection. The ureters and bladder have been laid open so as to expose to view the mucous membrane which lines them. The kidneys, however, are shown as they appeared before they were opened. On the surface of the right kidney (R) there are no evidences of the presence of tubercles in the cortical portion of the organ, but a few may be seen on the surface of the left kidney (L.) The ureter belonging to the latter appears to have escaped infection, unless the stricture at *LU* is to be explained as the result of tuberculous ulceration. On the other hand, the lining mucous membrane of the bladder and of the right ureter shows the presence of an abundant crop of tubercles.

The drawing as a whole is believed to illustrate an original blood implantation of tuberculosis in the left kidney; direct secondary infection, from this source, of the bladder; then an ascending ureteritis, pyelitis, and nephritis of the opposite (right) urinary tract.



POST-MORTEM APPEARANCES IN CHRONIC URINARY TUBERCULOSIS.

(CASE OF DR. F. TILDEN BROWN.)

[Organs moderately reduced in size in the drawings.]

lial cells, no casts or crystals, and *not a trace of other micro-organisms.* The examiner, after such a preliminary test, can feel pretty strongly assured that if now the future mounts are stained for tubercle bacilli some will be found sooner or later.

The pyrexia, except in the most advanced stages and when toxæmia is excessive, remains well within a range of two and a half degrees. Almost all of these patients have a faulty color even in the early stages, a combination of slight anæmia with softening of the tissues, a kind of flabbiness but not œdema. They are, however, frequently rotund and well-muscled. Of course, in the advanced stage, malnutrition and every evidence of excessive invalidism are marked.

By far the most striking symptom of renal tuberculosis is thamuria.* Commonly patients will maintain that they never had any urinary symptoms until they were suddenly aware of the obligation to urinate more frequently than had been their custom, and that this annoyance is just as great during the night as in the daytime, perhaps greater, and not infrequently they recount having had several recoveries from this frequency while each recurrence has been more persistent than the last.

This symptom is susceptible of a different explanation at two stages of the disease. At first, when the renal function is much stimulated by the recent tuberculous infection and before these lesions become large enough to rupture and communicate with the urinary channels, a sufficient polyuria may be maintained to tax the bladder capacity and thus lead to a relative degree of frequency. Again, when the renal lesions have become open ones, although they still cause a somewhat greater filtration of fluid than comes from the normal gland on the opposite side, the polyuria is not so marked as at first. Now, however, the slight but constant output of pus, bacilli, their toxins, and the general tuberculous débris, is probably in some cases sufficiently irritating to the base and neck of the bladder to cause frequency of urination. The writer once looked upon thamuria as the classical and almost pathognomonic symptom of renal tuberculosis. Further observation tends to show, however, that in the majority of cases this typical symptom does not appear until the lower segment of the ureter has acquired a genuine tuberculous lesion, or, at any rate, until marked hyperæmia and œdema have developed together with an irritable state of the mouth of the ureter, so that when the peristaltic waves of this tube, made unduly intense by the infectious lesion, are conveyed to and obliquely through a limited part of the bladder muscle, they become instrumental in exciting the detrusor muscles of the latter organ. As every inflammatory process seeks repose for its best comfort, it is probable that the pressure and increasing tension to which the diseased tissues at the mouth of the ureter are subjected by urinary accumulations in the bladder, furnish the main incentive to thamuria, it being assumed of course that the bladder itself and posterior urethra are exempt.

Diagnosis.—The diagnosis of the disease is absolute or presumptive. Although in eighty per cent. of cases the former is at the present day a result to be expected, there may be a remaining twenty per cent. in which, for reasons presently to be considered, patients must come to operation with only a tentative diagnosis.

Presence of the tubercle bacillus in the urine of either kidney, taken in connection with, or even without, most of the already mentioned symptoms, is the sole requirement for absolute diagnosis. Two events rendered this modern advance possible: first, Koch's discovery; secondly, the perfection of mechanical contrivances by means of which the urine of each kidney can be gathered from its ureter before commingling with that of its fellow in the bladder. In this way may be determined the diseased state of one or both organs as well as the functional capacity of each. The bilateral ureter-catheterizing cystoscope is the most effective instrument for accomplishing this purpose in both sexes, since not alone can the condition of the bladder, and especially that of the mouths of the ureters, be observed, but, by means of the flexible sterile catheters placed in the lower three inches of each ureter, both kidneys can be drained conjointly while the same nervous influences pertain and the same physiological processes are active. With specimens thus synchronously collected, minor quantitative and qualitative variations in the excretions of the two glands may be given a valuation they could not be allowed if the specimens were gathered in the still generally prevailing fashion, that is, by a single catheter used first on one side and then on the other.

In the presence of thamuria, that ofttime misleading symptom, it is proper to emphasize the importance of always looking beyond the bladder for its possible explanation, but particularly so when cystoscopy reveals an œdematous or hyperæmic state of one or the other ureter opening. Then one can be very nearly certain of finding the corresponding kidney diseased. But the existence of a normal ureter mouth does not preclude the existence of a kidney with open lesions in the early stage of tuberculosis. The ureter-catheter test is the only one which can determine in such cases the localization of the process.

Fig. 3068 shows the writer's latest modification of his original double-barrelled ureter cystoscope. For a fuller

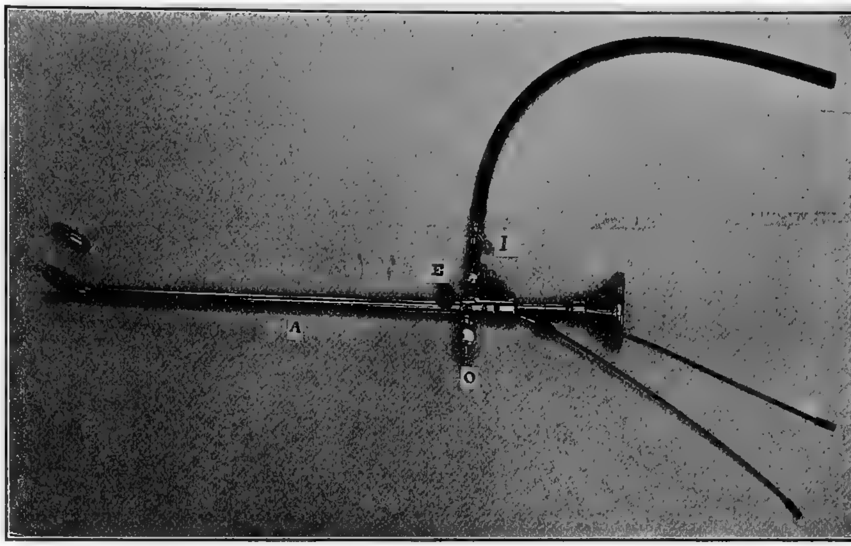


FIG. 3068.—The Writer's Irrigating Cystoscope for Bilateral Catheterization. *A*, Irrigation and light-carrying sheath for various telescopic parts; *E*, screw post for electric-light connections; *I*, inlet cock for water or air as bladder-distending medium; *O*, outlet cock for same.

* Θαμά, often, and οὖρον, urine, a substantive compounded by the writer in 1896, with the approval of Dr. Frank P. Foster. There had hitherto been no word to express frequency of urination, although some had used polyuria as a synonymous term.

description of the instrument and general technique see the "Presbyterian Hospital Medical and Surgical Reports" for 1902.

While separate urines are being collected in this way for chemical, microscopical, and perhaps animal-inoculation tests, it is well to let four or five drops from each ureteral catheter fall upon the media of blood serum tubes labelled right and left; for although the results of growing tubercle bacilli on special culture media as a means of diagnosis have not been sufficient to inspire general confidence, it is well to be informed in all suspected kidney cases as to the presence or absence of other pathogenic micro-organisms. Despite all these aids to diagnosis there are undoubtedly a few cases of renal tuberculosis, even with open lesions, in which the individual urine simply indicates the presence of a marked pyelonephritis, and nothing more. The specific bacilli are so sparsely shed as greatly to minimize the chances of detecting them by aid of the microscope. After removal of such a kidney it may require a very prolonged search to secure a bacillus or two, although tubercle tissue is quite general. Dr. Bolton's case was one of this kind (see *Annals of Surgery*, June, 1900, p. 749). In such an instance even animal inoculation might prove negative unless practised on a large scale, while the less positive tuberculin test would probably be affirmative.

Then there are some cases in which the disease begins as a plainly evident urinary tuberculosis, but in which there are such advanced and painful vesical and urethral lesions as to defeat all efforts to secure the separate urines by cystoscopic ureter catheterization. In cases like this, if suprapubic drainage is established to secure repose of the bladder, advantage should be taken of the presence of an opening and of the existence of full anæsthesia for the introduction, if possible, of the ureter catheters, because, if one kidney is thus found to be tuberculous and the other healthy, a nephrectomy will yet afford the best chance for prolongation of life and comfort (see Boston *Medical and Surgical Journal*, May 30th, 1901, p. 515). But merely resorting, in a case of renal tuberculosis, to epicystotomy for the relief of vesical spasm is an illogical procedure; nothing can be gained by it so long as tuberculous products continue to descend into the viscus from above.

Dr. F. C. Wood says, in respect to tuberculin as an aid to diagnosis in this disease, that its injection, for the purpose of determining the presence or absence of a genito-urinary tuberculous lesion, has come widely into use. The normal temperature variations of the patient are first determined for twenty-four hours, preferably by hourly observations; after the injection the temperature must again be taken at intervals at least equally frequent or a slight reaction may be overlooked. The original Koch's tuberculin, which is a glycerin extract of the bodies of the tubercle bacilli, is to be used, and not one of the newer preparations. One-half to one milligram of the tuberculin is to be injected, the smaller quantity in children, the larger in adults. These quantities can be easily measured by properly diluting the original strong solution. The injection should be made into the deeper tissues with a hypodermic syringe which has been sterilized by boiling. If after the first injection a rise of temperature of 0.5° C. is observed the diagnosis of a tuberculous lesion is probable. This rise regularly occurs within the first thirty-six hours after the injection, usually within four or five hours. If no rise is observed a second or even a third injection may be given, with a dose not to exceed 10 mgm.; anything above this will cause a rise of temperature in healthy adults. A positive result affords very strong evidence of an active tuberculous lesion in the body; a negative result is not quite so valuable, as in a certain number of cases of old encapsulated tuberculous lesions a positive reaction does not occur, even when considerable doses are administered. This is probably due to the poor circulation in such nodules which prevents the escape of the toxins of the bacilli and equally the entry of the tuberculin.

The careful use of well-prepared tuberculin is not dangerous. It contains no tubercle bacilli. Unfortunately the significance of a positive reaction is in these renal cases not always so strong as could be wished, since it has been well established that a considerable proportion of individuals showing no evidence of pulmonary tuberculosis have focal and quiescent lesions of the apices and pleura.

An element of confusion which does not come into consideration in the case of properly collected ureter-catheter specimens of urine, occupies an important place in the records of all the earlier steps leading to a diagnosis of genito-urinary tuberculosis in general. This is the smegma bacillus, a micro-organism which occurs with great constancy and in varying numbers in the smegma of the prepuce of the male, in the grooves between the labia majora and minora in the female, and about the perineum and anus of both sexes. It has also been demonstrated in the cerumen of the ear, on cutaneous surfaces, and in various parts of the body, especially in the folds of the groin, the armpits, and the grooves of the umbilicus, and also on the mucous membrane of the mouth. Careful examination of the sediment of voluntarily voided urine will, in most cases, reveal the smegma bacillus. For obvious reasons the urine of females contains larger numbers of this organism than that of males. Grünbaum found them in the sediment of centrifuged urine of females in fifty-nine per cent. of the specimens examined.

They may be readily stained by basic aniline dyes; carbol-fuchsin gives the best results. The most striking peculiarity of this bacillus is its remarkable resistance to decolorizing solutions; in which respect it resembles the tubercle bacillus. The red color of aniline-fuchsin stain may often persist for some time after the specimen has been subjected to the action of five-per-cent. sulphuric acid, twenty-per-cent. nitric acid, alcoholic sulphuric acid, alcohol, or other decolorizing agents. It is, however, a well-established fact that the smegma bacillus is somewhat more sensitive to acids than the tubercle bacillus, and on this fact were based the numerous earlier differential stains. But it remained for Grethe to show, in 1896, the unreliability of these methods and that the difference in the resistance of the two organisms to acids is an exceedingly slight one. At the same time he showed that the smegma bacillus loses its stain much more readily than the tubercle bacillus when the specimens are treated with alcohol. Of the many differential stains based on this principle, the following procedure can be recommended: (1) Stain the specimens with carbol-fuchsin, heating gently; (2) pour off the excess of dye and decolorize the specimen with ten-per-cent. sulphuric or nitric acid; (3) remove the excess of color with strong alcohol; (4) treat the specimen with aqueous methylene blue; (5) examine for bacilli stained red and mark the field containing them; (6) place the specimens in strong alcohol for eight hours and re-examine the marked fields which contained the red-stained bacilli. If, on the second examination, the bacilli are still red, it may be assumed that the organisms are tubercle bacilli and not smegma bacilli.

A second method advocated by Wood is that of Pappenheim and depends for differentiation of the two organisms on the combined decolorizing effect of alcohol and rosolic acid (known also as corallin and aurin): (1) Spread on a slide and fix as usual. Stain with hot carbol-fuchsin for two minutes; (2) pour off the surplus dye without washing; (3) counterstain and decolorize by pouring over the slide, from three to five times, a one-per-cent. solution of corallin in strong alcohol; saturate the above solution with methylene blue and add twenty parts of glycerin; (4) wash off in water, dry with blotting paper and then in the air, and examine. The tubercle bacilli are stained red, the smegma bacilli blue.

All specimens of urine which are to be examined for tubercle bacilli should be obtained through a catheter to avoid contamination with the smegma bacillus which exists in the most anterior portions of the urethra and external genitals. The external urethral orifice should be

cleansed with some antiseptic solution and the urine obtained through a sterile catheter. The importance of these precautions is shown by Bunge and Trautenroth, who, examining in this way, found the urine constantly free from the smegma bacillus. It is advisable to precipitate the sediment by centrifuge, then to make cover-glass preparations, and finally to stain them by one of the methods mentioned. It is important that the urine be examined as fresh as possible, since alterations in the reaction somewhat affect the staining properties of the tubercle bacillus.

It is well to centrifuge a good quantity of the suspected urine. If much thick pus is present in the urine the method of Biedert for softening is recommended. This consists in gently heating the thick sediment with a small quantity of a ten-per-cent. sodium-hydrate solution, until the pus is changed into a thin and fluid consistence. The mixture is centrifuged and the supernatant fluid poured off, and the sediment is then washed with distilled water, thus removing as much of the alkali as possible. A small amount of thin egg albumen is added to the sediment. This facilitates the fixation of the bacilli to the slide when heat is applied.

It is now a well-established fact that the direct examination of urinary sediment for tubercle bacilli can be utilized to only a very limited extent, and it is always open to certain sources of error. The inoculation of the sediment into guinea-pigs is the most reliable test at our disposal, and when possible it should always be made. The inoculation may be made subcutaneously below the folds of the groin. This has the advantage over the intraperitoneal inoculation in that the animals are less likely to die from other infections, and it also permits of a somewhat earlier diagnosis of the tuberculous lesions. The inguinal glands are first involved, and these may be examined at the end of three or four weeks for tubercle bacilli without sacrificing the animal.

Prognosis.—This varies according to circumstances, in individual cases, from very bad to fair, but while proper treatment is of great moment, it may be said that under any form of treatment now known the ultimate prognosis can seldom be good. This is because, despite what may promise at the time to be a successful removal of localized disease by a uretero-nephrectomy, the chances are that some other unrecognizable tuberculous focus exists, liable at some future moment to make trouble.

The occasional extreme chronicity of renal tuberculosis, together with the fact that intervals of improvement may alternate with exacerbations of symptoms, makes any decided opinion ill advised as to just what the patient's condition will be six months or a year later with or without treatment. For a review of some cases that show this see the Boston *Medical and Surgical Journal*, May 30th, 1901, p. 513.

While recognizing the pathogeneity of germs, I must emphasize the fact that two appreciable but as yet immeasurable factors have to do with their presence: first, the variability of germ species or their degree of virulency; second, the variability in the resisting power possessed by the tissue soil of different individuals.

Important experimental researches bearing on the former have been made by Theobald Smith, Lartigau, and others, but as yet they have given us no practical working basis for establishing a prognosis. And as for the second factor, I venture to express the hope that the same may not have to be said of Koch's latest individual work on immunity and agglutination in tuberculosis, for it appears to be established in this disease that intensity of agglutination and degree of immunity stand in direct relation to each other. When this test is on a practical footing and can be applied in a routine manner to all clinical material after a positive and localizing diagnosis has been made, it may then be necessary to rewrite the following remarks on treatment.

Lampugnani concludes from an analysis of the diazo reaction, as it occurred or failed to occur in a large number of sick and healthy individuals, that it is of some value in the prognosis of tuberculosis; for in twenty-six cases of the pulmonary form the reaction occurred in nine, and in all of these nine a fatal result soon followed.

Treatment.—If in the early stage of this disease absolute physiological rest could be given to the organ, as practised in similar disease of the joints, while at the same time the patient's greatest vitality is maintained by hygienic and climatic resources, we might, reasoning from analogy, expect a certain number of cures to take place. This chimerical scheme is only mentioned as a partial explanation for the writer's belief that there is little to be hoped for except from surgery. If the dangerous kidney can be detected and removed before any other part of the urinary tract is contaminated, the individual will certainly be in the safest possible condition, although a dormant focus may lie undetected in some other part of the body.

Even when the diagnosis is not made until the corresponding ureter and part of the bladder are involved, the majority of surgeons recommend, when the opposite kidney is healthy, as early and complete a uretero-nephrectomy as possible. And the greater the experience of a surgeon in these cases the more inclined is he to take greater chances in attempting to prolong life by removing a kidney that is badly diseased, and that serves as the source of a constantly increasing toxæmia, even when the opposite organ is known to be affected, but to a less extent.

FIG. 3069.—Anterior Incision, Extraperitoneal Nephrectomy, Three Weeks after Operation. Nine years previously the right breast had been partially excised for tuberculous disease. (Writer's case.)

The writer has had a recent experience (*Annals of Surgery*, May, 1902, p. 638) which illustrates this point. In this particular case benefit had first been sought by hygiene and climate, then by an operation which consisted in dividing the right ureter near the bladder and giving it an outlet in the lumbar region (Fig. 3069); but the only result of the operation was that absorption from the bad right kidney was more ominous than it had been before. Removal of this right urinary tract was then effected with surprisingly good result, although the left kidney was diseased.

The writer has never had reason to regret the operation of nephrectomy in any of his seven cases of tuberculosis; while in a few instances in which the operation was either not advised by him or not accepted by the patient, he has seen exacerbations or disasters follow which he believes would have been prevented by nephrectomy.

It is unnecessary to say more than a word regarding partial nephrectomy and nephrotomy in this disease. The former is a more dangerous surgical procedure than complete nephrectomy. In case of a tuberculous kidney, with pus escaping into its pelvis, a sudden occlusion of the ureter may call for immediate nephrotomy, but the expectation of getting any progressive benefit

for such a case by lumbar drainage is apt to be fallacious.

The details of the operation of nephrectomy will be dealt with in the next article. In the present place it is only pertinent to add that, in general, anæsthesia with nitrous oxide gas and ether is to be preferred. Whatever the site and shape of incision selected, the kidney and any desired portion of its ureter should be removed extraperitoneally. Both the ilio-hypogastric and ilio-inguinal

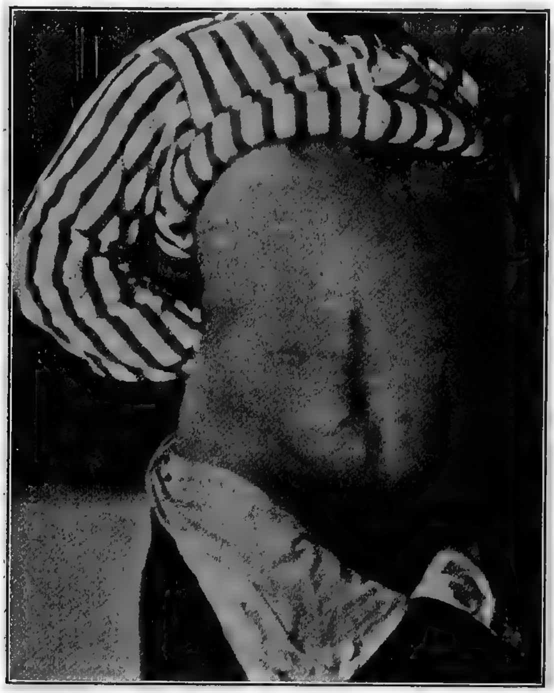


FIG. 3070.—Anterior T-incision; Extraperitoneal Nephrectomy. Photograph taken two years after the operation and fifteen years after an operation for appendicitis. (Writer's case.)

nerves should be spared severance. The costo-iliac oblique incision offers the simplest access to the kidney,—less stripping of parietal peritoneum being required,—but the patient's posture is here one which sometimes involves an undesirable amount of pressure on the opposite kidney; and besides, if much of the ureter is found diseased and its removal is practised, the necessary extension downward of this incision severs the internal oblique and transversalis muscles more or less transversely. Mainly for these reasons the writer prefers to maintain the patient in the dorsal position and to employ an antero-lateral incision which conforms to the costal margin, and by means of which, after the skin has been divided, some degree of intermuscular separation can be effected. After stripping forward the parietal peritoneum good access is given to the kidney. Fig. 3069 shows the cicatrix after such a nephrectomy.

In cases in which it is found necessary to perform a considerable ureterectomy in addition, the usual preliminary incision may be made as if for a nephrectomy, and then the inner extremity of this incision should be extended at right angles downward along the outer border of the rectus muscle for the necessary distance, exposing the peritoneum to be separated and deflected toward the median line.

Any tear of the peritoneum calls for immediate closure by a continuous catgut suture.

If a tuberculous kidney has its ureter similarly and continuously diseased beyond the sacral brim we are not disposed to urge that a total extirpation of the ureter should then or even at a later operation be attempted. Numerous operators have observed that the leaving of a considerable amount of tuberculous ureter has been followed by no subsequent detriment. This is explained by the supposition that removal of the kidney has left the ureter in a functionless state of repose and amenable to the curative processes of systemic invigoration. At the same time sufficient experience has not accumulated to warrant us in maintaining that a routine practice based on this presumption is always the best surgery. If it were not for the fact that a total removal necessitates such an increased operative exposure, the more radical step would better satisfy the surgical indications present in these cases, and at the same time would afford a satisfactory method of dealing with any remaining tuberculosis.

When the other kidney is in a satisfactory condition—and information on this point should always be sought well in advance of any surgical procedure—the operation itself is a comparatively safe one, certainly safer than nephrectomy undertaken for any other cause. The writer has had seven such cases without a death, while the mortality in his cases of nephrectomy and nephrotomy for other diseases has convinced him of a marked difference in the dangers attached to renal surgery.

Cases are met with in which, with the removal of a tuberculous kidney, all the vesical symptoms, especially thamuria, have disappeared. This has not been the happy result in the majority of the writer's cases, although the frequency of micturition has lessened and repeated microscopic and animal-inoculation tests during a period of two years and more have failed to show remaining tuberculosis of the urinary tract. A satisfactory explanation of this persistence of frequency of micturition is yet to be made. The claims are that any one of several causes may be the controlling factor in different cases. The value of training such bladders to tolerate greater degrees of distention by the daily use of warm

FIG. 3071.—Abdominal Wound after Lumbar Transplantation of the Ureter. In the loin is a ureter catheter draining a tuberculous kidney. Patient in bad condition. Subsequent nephrectomy followed by unexpected restoration despite disease of left kidney. (Writer's case.)

boric-acid solutions, introduced by siphonage or gravity flow, has been evident in the writer's experience. French writers have recently advocated inflation of the bladder with air in such cases. But, unless the medium is previously warmed, the writer would suggest caution in such a procedure.

In connection with the subject of treatment it is only fair to state that some authorities maintain that a certain

Kidneys.

number of the patients who suffer from tuberculous disease of the kidneys make complete clinical recoveries under the simple influences of change in climate and altered hygienic conditions, and they advocate, therefore, that operative interference be resorted to only after these measures have been given a thorough trial. It is plain, however, that in the majority of instances the question of expense will make it impossible for these patients to adopt such a course. For them the best plan is to spend a few weeks under the improved hygienic influences of a properly organized hospital and then to undergo a suitable surgical operation. Afterward, if arrangements can possibly be made by the patient to secure the benefits, for a period of several months or for life, of a residence in a better climate and under good hygienic influences, such a course should by all means be adopted.

F. Tilden Brown.

KIDNEYS, INJURIES OF. See *Abdomen. (Surgical.)*

KIDNEYS, SURGICAL AFFECTIONS OF.—The operative treatment of diseases of the kidney has developed to such a degree within the past few years as to make it

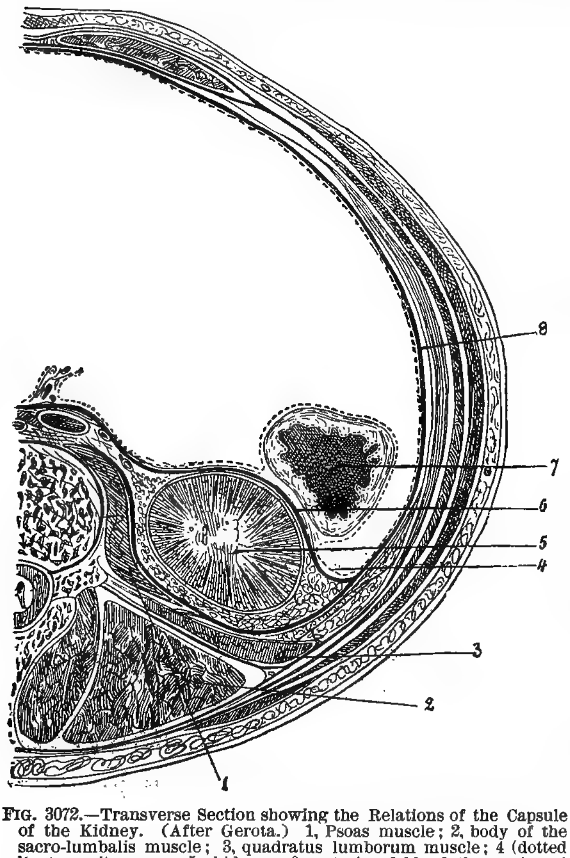


Fig. 3072.—Transverse Section showing the Relations of the Capsule of the Kidney. (After Gerota.) 1, Psoas muscle; 2, body of the sacro-lumbalis muscle; 3, quadratus lumborum muscle; 4 (dotted line), peritoneum; 5, kidney; 6, anterior fold of the perirenal fascia; 7, colon; 8, subperitoneal fascia.

desirable to discuss the subject in detail. It will therefore be considered under the headings of Surgical Anatomy, Methods of Examination, Operative Technique, Effects of Operation, Movable Kidney, Hydronephrosis, Suppuration, Paranephritis, Calculus, Essential Hemorrhage and Nephralgia, Aneurism, Syphilis, Cystic Tumors, and Suprarenal Gland.

Surgical Anatomy.—The anatomy of the kidney is considered in a separate article, but it is worth while to emphasize certain facts in the structure and relations of the organ, a knowledge of which is essential to the proper understanding and treatment of its surgical diseases.

The chief support of the kidney is the fibrous capsule which surrounds the gland as far as the hilus and sends a firm prolongation behind the renal vessels to join with the sheath of the aorta and the fascia which covers the

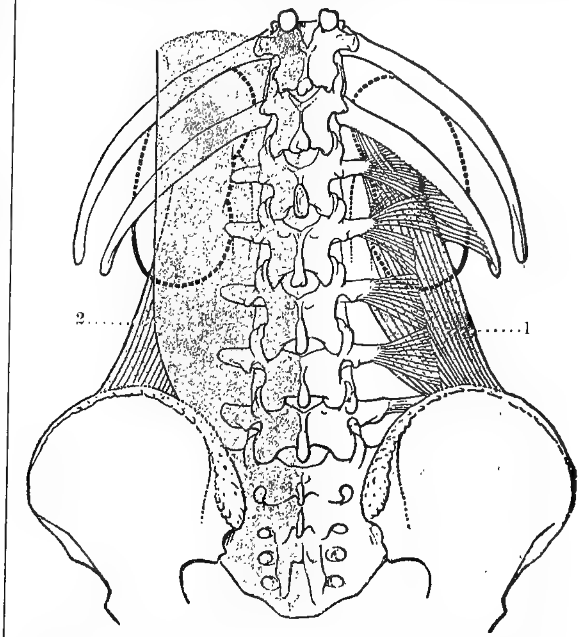


Fig. 3073.—Situation of the Kidneys. (After Récamier.) 1, Quadratus lumborum muscle; 2, sacro-lumbalis muscle.

pillars of the diaphragm. This fibrous prolongation acts as a suspensory ligament to maintain the kidney in position (Fig. 3072).

The kidney normally occupies a position between the level of the spinous process of the eleventh dorsal vertebra and that of the spinous process of the second lumbar vertebra, being situated slightly lower on the right side than on the left.

The lowest point of the pleural cavity is where it touches the eleventh rib some four or five inches from the median line. Hence the upper portion of the kidney lies very close to the pleural cavity, especially on the left side.

The relation of the colon to the kidney may be of importance in the diagnosis of abdominal tumors. It is commonly stated that the ascending colon crosses the lower pole of the right kidney, and the descending colon crosses in front of the left kidney. But this rule is by no means invariable. The ascending colon may lie wholly below the right kidney, and the descending colon may cross entirely above the left kidney. Hence the distention of the colon with air pumped into the rectum is not an infallible means of differential diagnosis between such conditions as a tumor of the right kidney and a constricted lobe of the liver, or an enlarged spleen.

The vascular supply of the kidney is variable. According to Jössel the renal artery has two anterior branches, one superior branch, and one posterior branch; but this is by no means a universal arrangement. Indeed, there are often two and sometimes three renal arteries (Fig. 3074). While the renal artery or its branches usually enter the hilus, there is often a separate artery to one or the other pole which may escape ligation and give rise to troublesome hemorrhage when the kidney is removed.

One definite condition of the arterial supply is the fact that all branches are terminal branches. Hence if one of them is cut, necrosis of the pyramidal-shaped portion of the parenchyma which it supplies will follow.

In opening the kidney along its convex border, the incision should be made between the areas of distribution

of the different branches. The best line of incision, therefore, does not follow the crest of the convex border, but lies about one-third of an inch posterior to it.

Methods of Examination.—While inspection of the lumbar region may give some hint as to the diagnosis of renal trouble, bimanual palpation is a far more valuable method of examination. The patient should assume a position in which the abdominal muscles will be relaxed, and in which the kidney will sink downward as far as possible. Three positions accomplish these results more or less perfectly. The patient may lie on his back in a semi-recumbent position, or he may lie on his side turned slightly toward his face, or he may sit on the edge of a chair and lean well forward, resting his head upon his crossed arms placed upon the back of a chair or upon a table. The surgeon places one hand just under the twelfth rib and the other opposite to it on the front

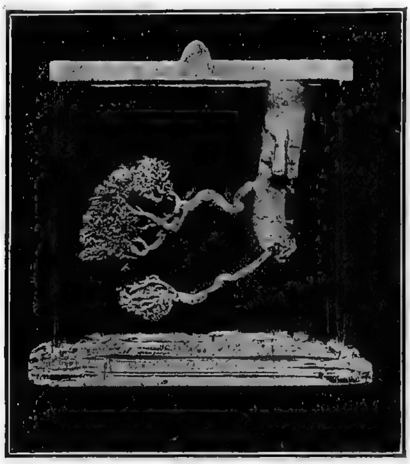


FIG. 3074.—Corrosion Preparation of the Renal Vessels showing a Separate Artery to the Lower Pole. (Zondek).

of the abdomen. If the kidney is displaced downward or is much enlarged or is movable, it will easily be felt by one of these methods of examination. An anæsthetic is necessary only in case the patient is unable, because of pain or for other reasons, to relax the abdominal muscles.

The normal kidney is palpable in the case of a few men and most women. The figures given for the right kidney are eight per cent. for men and eighty per cent. for women, while the figures for the left kidney are six per cent. for men and thirty per cent. for women. Becker and Lennhoff assert that most of the kidneys which are palpable are found in persons with a long, slender trunk. "If the distance from the suprasternal notch to the symphysis pubis be divided by the smallest circumference of the abdomen the index figure obtained will vary from sixty-three, or less, to ninety-five." * A kidney is rarely palpable unless the index figure of its possessor is over seventy-five.

The *x*-ray has already proved itself to be a valuable aid to diagnosis, especially in the case of renal calculus, and it is likely to become more serviceable for this purpose as operators learn to differentiate more nicely between tissues. Calculi composed

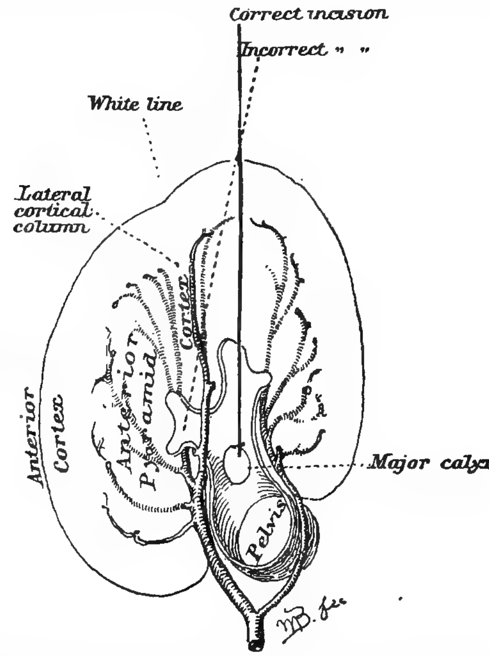


FIG. 3075.—Section Through a Kidney, showing the Correct Position and Direction of an Incision into its Pelvis. (From Kelly.)

of oxalates are easily shown by means of the *x*-ray. Those composed of phosphates give a fainter shadow, while those composed of uric acid are the most difficult to bring out in the radiograph.

Examination of the urine is of course of the greatest value in the diagnosis of surgical affections of the kidney. It is often necessary to obtain the urine from a single kidney, which may be done by catheterization of each ureter (see article on *Cystoscopy*), or by making

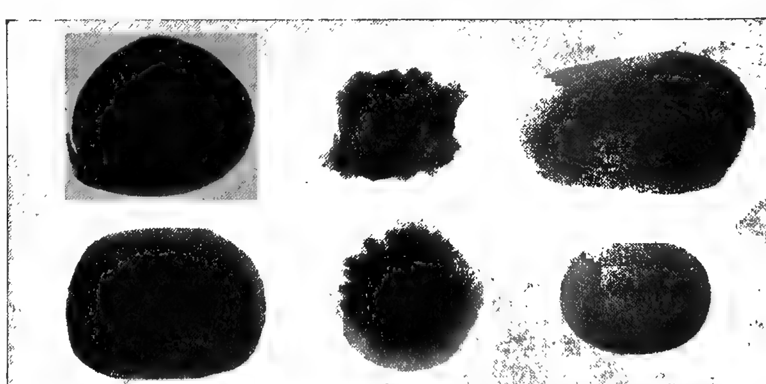


FIG. 3076.—Radiograph of Calculi from the Pelvis of the Kidney. The two on the left are composed of uric acid and urates; those on the right of phosphates. The two calculi in the middle are composed of oxalate of calcium and uric acid, the upper one having an outside coating of urates. (From "The Roentgen Rays in Medicine and Surgery," by Francis K. Williams, M.D. Macmillan, 1901.)

a ridge in the base of the bladder and drawing the urine from either side of it as it flows from each ureter.

When the urine has been obtained separately from the two kidneys it may be tested chemically, microscopically, physically, and bacteriologically, according to the established rules. There are also two modern methods of

* Thus, for example, if the distance between the first two points is 22 inches and the girth of the abdomen 32 inches, the index figure will be 68 $\left(\frac{22}{32}=0.68\right)$.

determining the functional activity of the kidney, which are of the greatest value in deciding the question of extirpation of one organ. The first is the injection subcutaneously of 0.005 gm. of phloridzin in a solution having a strength of 1 : 200. If a kidney is normal it excretes sugar in the urine within a half-hour. The percentage of sugar in the urine is a reliable test of the functional activity of the kidney. The urine must of course be collected from the two kidneys separately, if the functional capacity of each is to be shown.

FIG. 3077.—*x*-Ray Picture of a Renal and a Ureteral Calculus. (From Dr. Alexander B. Johnston's article in the *Annals of Surgery*). In the left kidney there was a large calculus which formed a cast of the dilated pelvis and calyces; in the ureter of the same side there was a stone. The patient, a man forty-one years of age, weighed about one hundred and forty pounds.

Another valuable means of estimating the functional activity of the kidneys is to determine the freezing point of the blood and of the urine. The freezing point of normal urine is from 1° to 2.3° C. below that of distilled water. If the freezing point rises it indicates that the work of the kidneys is insufficient. The freezing point of the blood is less variable in health than that of the urine, and hence is a more certain guide to urinary excretion. Normally it is 0.56° C. below that of water. If the activity of the kidney is deficient the blood will contain more than the normal proportion of salts which ought to have been excreted, and hence its freezing point will fall. A drop of 0.03° or 0.04° is good proof that both kidneys are acting insufficiently; and if the freezing point is lower than this, one organ ought not to be extirpated unless it is known to contain no parenchymatous tissue. The best apparatus to determine the freezing point is that devised by Beckmann.

Operative Technique.—Schede mentions seven operations which may be performed for diagnosis or treatment in the case of renal disease. These operations are (1) incision into a paranephritic abscess; (2) evacuation of extravasated blood or urine in the case of traumatism; (3) nephropexy, or fixation of a movable kidney; (4) incision of the contracted capsule in order to relieve renal neuralgia; (5) nephrotomy or pyelotomy, that is, incision into the pelvis of the kidney, through the cortex or directly, to remove a calculus or to afford drainage in case of suppuration; (6) resection of a portion of the kidney for diagnostic or therapeutic reasons; (7) nephrectomy, or extirpation of the whole kidney, an operation which may be necessitated by traumatism, hydronephrosis, suppuration, calculus, ureteral fistula, tuberculosis, or malignant new growth.

As the anterior surface of the kidney is partly covered with peritoneum the organ can be reached from in front through an abdominal incision, or through an incision made in the lumbar region. The usual laparotomy incision in the median line may be employed, or one may be made along the outer border of the rectus muscle, or the operator may resort to the oblique incision of Trendelenburg, extending from the costal margin in the anterior axillary line to the pubic spine. This incision gives the best access to the organ. The posterior peritoneum is divided outside of the colon and the colon is pushed toward the median line out of the way.

Some surgeons advocate one method for certain operations, and some another. Each method has certain advantages and disadvantages which must be admitted by all. The transperitoneal method gives a good exposure of the diseased kidney and enables the surgeon to examine other abdominal organs, and especially the other kidney. In the removal of very large tumors there is probably a saving of time if the transperitoneal method is followed. This method is said to give the surgeon a better opportunity to remove diseased lymphatic glands in the neighborhood of the vena cava.

A disadvantage of the method is the risk of infecting the abdominal cavity from septic matter which may be contained in the kidney. Moreover, the necessity of handling and possibly of tearing the abdominal organs in the efforts to get at the kidney should also be taken into consideration. If the kidney is removed there will be left a retroperitoneal cavity left which require drainage either through the loin or through the abdominal wound. This is at best an awkward procedure. Abdominal drainage will be followed by adhesions between the anterior and posterior layers of peritoneum. This scar may later be dissected out and the wound in each layer be sutured by itself (Heidenhain).

The lumbar method, provided it is carried out without any injury to the peritoneum, saves the abdominal cavity from the risk of infection. The shock to the patient is less than when the abdominal cavity is opened. If it is necessary to examine the other kidney, the peritoneum may be divided sufficiently to allow the operator to pass his hand through the lumbar wound into the peritoneal cavity. When the examination is completed the peritoneal wound may be sutured. This can be done before the diseased kidney is cut into, and therefore with only

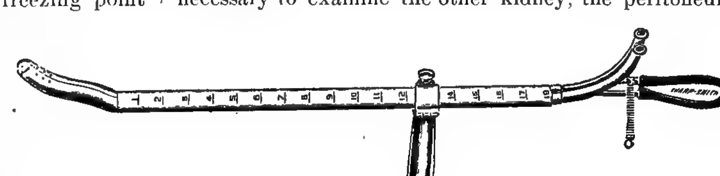


FIG. 3078.—Harris' Instrument for Obtaining Urine from the Two Ureters Separately. The two catheters are placed side by side for ease of introduction through the urethra. *Journal of the American Medical Association*, January 29th, 1898.)

slight risk of infection. The other kidney may also be examined through an incision in the other lumbar region.

Objections which have been made to the lumbar method are based upon the fact that it is difficult to expose and to remove an enlarged kidney in this manner. This criticism was doubtless true of many of the lumbar incisions previously employed, but at the present time the method has been so perfected that so experienced a man as Israel uses it altogether, while Schede recommends it for all operations excepting those per-

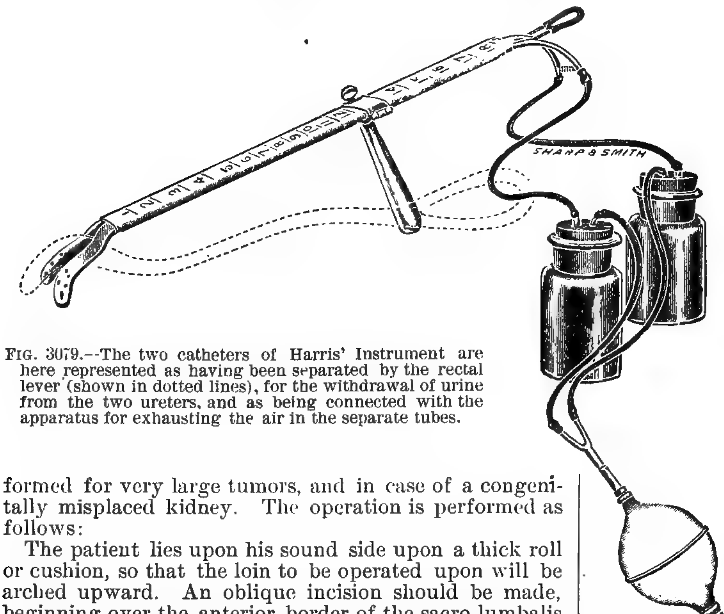


FIG. 3079.—The two catheters of Harris' Instrument are here represented as having been separated by the rectal lever (shown in dotted lines), for the withdrawal of urine from the two ureters, and as being connected with the apparatus for exhausting the air in the separate tubes.

formed for very large tumors, and in case of a congenitally misplaced kidney. The operation is performed as follows:

The patient lies upon his sound side upon a thick roll or cushion, so that the loin to be operated upon will be arched upward. An oblique incision should be made, beginning over the anterior border of the sacro-lumbalis muscle just below the margin of the twelfth rib and extending downward and forward parallel to the rib. The incision may be extended until it reaches the anterior axillary line; or, if this is not sufficient, it may be prolonged still farther forward and downward. The sacro-lumbalis muscle is felt with difficulty in stout persons. It is well to remember that this anterior border is from 2.5 to 3 inches from the spinous process of the first lumbar vertebra. The subcutaneous fat is divided, after this the superficial fascia, and then the latissimus dorsi muscle, which in this situation is not more than an eighth of an inch in thickness. The firm fascia covering the sacro-lumbalis muscle is next divided and the rounded edge of the muscle exposed. It may be necessary to ligate the twelfth intercostal and first lumbar arteries as they pass into the quadratus lumborum muscle close to its insertion near the twelfth rib. The retroperitoneal connective tissue is exposed and the peritoneum is pushed forward out of the way. If the ribs interfere with free access to the kidney a portion of the twelfth and even of the eleventh may be removed. Care should be taken not to injure the diaphragm or to open the pleural cavity. This accident is not a very serious one, however, and the rent may be sutured immediately, or plugged with gauze and sutured later. The fatty capsule being exposed, it is divided, and the kidney is separated from the fatty capsule by a blunt dissection. If fibrous bands are found, especially about the lower pole, they should not be cut through until ligatures have been placed around them, since they often contain good-sized vessels. When the kidney has been freed as far as the hilus it can be brought up into or out of the wound to permit inspection.

If the kidney is a movable one which is to be fixed in position, a strip of the capsule may be marked out with the scalpel and peeled off and the organ fixed in position by sutures which pass well through the parenchymatous tissue and through the strong layers of fascia and muscle on either side of the lumbar wound.

If nephrotomy is to be performed the incision should be made about one-third of an inch back of the convex margin of the kidney, and in a plane parallel to its posterior surface so as to avoid wounding arterial trunks (see Fig. 3075). The ureter may then be explored from within the pelvis of the kidney, or it may be palpated externally by continuing the blunt dissection downward.

A section of the kidney may be removed for microscopical examination or because it is diseased. The terminal arrangement of arteries in the kidney explains the occurrence of a local tuberculosis, and when this exists an early resection of the diseased portion may rid the patient of his trouble, while preserving a considerable part of the affected kidney.

If the kidney is to be drained it may be left in its natural position or sutured in the subcutaneous portion of the wound.

In extirpation of the kidney the organ is exposed, freed, and, if possible, brought into the wound in the manner already described. The vessels of the ureter will then be exposed, the renal vein lying anteriorly, the artery next, and the ureter farthest behind. These should be ligated separately. They may then be divided, and the kidney, being entirely freed, may be lifted out of the wound.

There are cases in which, on account of adhesions, it is difficult to bring the kidney out of the wound. The plan of procedure should then be to divide such small sections of tissue as are visible, and to ligate their vessels. This can usually be done if the assistants hold the edges of the wound well apart. As far as possible one should avoid cutting in the dark. It is even better to pass an elastic ligature around the whole pedicle and to remove a portion of the organ if thereby space is gained to enable the surgeon to see where he is cutting. Too great tension should not be brought upon the pedicle, as instances are recorded in which this has suddenly parted and fatal hemorrhage has followed.

The general rule is to carry out the dissection between the fibrous and fatty capsules. In some instances the two are so adherent that it is better to shell the kidney out of its fibrous capsule, while in case of tuberculous or malignant disease one naturally removes with the kidney as much of the fatty capsule as possible.

The oblique incision described above is the simplest, and in many respects the best lumbar incision. Some surgeons prefer a transverse incision, some a T-incision, and some an angular incision, the longitudinal portion of which extends along the border of the sacro-lumbalis and then bends sharply to follow the crest of the ilium, or extends upward along the costal margin, as the case may be.

Effects of Operation.—The immediate effect of removing one kidney is to diminish the urine to about one-

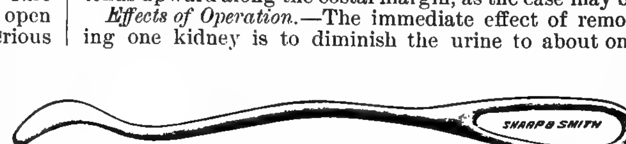


FIG. 3080.—The Rectal Lever, for making a Watershed in the Bladder.

fourth of the previous daily quantity. If the case progresses favorably the quantity of urine gradually increases until in five or six days it is normal and contains the normal amount of urea. There are, however, many variations from this type: thus, if the kidney which is removed has not for a long time excreted any urine, the effect on the other kidney may be insignificant.

If the case progresses unfavorably, the quantity of urine which during the day following the operation is perhaps ten or twelve ounces, may fall on the second day to half of that amount, while on the third or fourth day there may be total anuria with speedy death. Microscopic examination of the remaining kidney will show extensive degeneration of the convoluted tubules.

Sometimes the patient will apparently do well for a week or two and will then begin to pass a gradually decreasing quantity of urine which contains hyaline and waxy casts and degenerated renal epithelium. A few days later, anuria will be complete and death results. The remaining kidney under these circumstances will show signs of degeneration, not only of the convoluted tubules, but also of the straight tubules and of the glomeruli. But not all of these patients with unfavorable symptoms die. There are cases in which insufficient urinary excretion continues for some time and then gradual betterment takes place.

When a patient recovers from nephrectomy the remaining kidney undergoes hypertrophy. It was at one time supposed that this renal enlargement was due to a new formation of tubules and glomeruli. Such is not the case. A tubule may increase in size and length from multiplication of its cells, but there is no good evidence that new tubules or new glomeruli are formed.

When a kidney is incised and drained, urine will flow from the wound for a variable length of time. If there is obstruction in the ureter, the flow from the wound will be permanent. If the ureter is open and there is no disease in the kidney—tuberculosis, for example—the urinary flow from the wound will grow less and less and finally cease altogether. Such is the usual result after nephrotomy for renal calculus.

Movable Kidney.—The normal kidney moves with respiration, and if the patient is not too fat, and has a wide space between the crest of the ilium and the margin of the ribs, and especially if the abdominal walls are lax, the normal kidney may often be palpated. The etiology of movable kidney is a widely discussed subject. In the first place it is noticeable that eighty-five per cent. of the cases of movable kidney occur in women. In the second place movable kidney occurs about fifteen times as often on the right side as on the left. The kidney is normally held in place by a fascial prolongation from its fibrous capsule to the spinal column (see above) and also, according to Wolkoff and Delitzin, by the shape of the recess in which the kidney lies. The normal recess is slightly funnel-shaped. In a case of movable kidney the recess is shallow and more cylindrical. Other alleged causes are reduction of the intra-abdominal pressure by relaxation of the abdominal walls, tight lacing, especially if so carried out as to compress the ribs, and muscular strains and blows.

A movable kidney may be recognized bimanually if the patient is placed in one of the three positions mentioned above. It can be easily crowded back into its normal position, and will often return there without manipulation if the patient lies flat upon his back. A movable kidney causes discomfort, and a dragging pain in the lumbar region and back which is worse after long standing and is increased by heavy lifting. These symptoms are much relieved by rest in a recumbent position. At other times a kidney will be movable to a high degree without giving rise to symptoms. Most of the patients who complain of movable kidney suffer from a disordered digestion, and are of a neurasthenic type. It is often impossible to say just how many of the symptoms complained of are really caused by the kidney.

A movable kidney may become strangulated by twisting upon its pedicle. The congestion and œdema and perhaps urinary obstruction which follow produce an intense and at times unbearable pain. Such an attack of strangulation is accompanied by anuria. The attack usually passes off in a few hours and is followed by a greatly increased flow of dilute urine.

The treatment of an attack of strangulation of this character is rest in bed, the local application of ice, and the hypodermic administration of morphine. In a few instances a surgeon has been able bimanually to untwist the pedicle of the kidney and thus to relieve the strangulation. The twist sometimes occurs in one direction and sometimes in another.

Palliative treatment of movable kidney consists in the avoidance of jars and undue muscular exertion, the improvement of the digestion, and, if possible, increase in body weight, since emaciation is an important factor in the development of movable kidney. A well-fitting abdominal bandage will often give a patient a good deal of comfort. Attempts to hold the kidney in place by means of a pad are generally unsuccessful and frequently add to the patient's discomfort by reason of the pressure which the pad makes upon the kidney which has slipped down beneath it.

More than twenty years ago Hahn attempted to fix a movable kidney by passing catgut stitches through the posterior part of the fatty capsule. The operation in this crude form has been variously modified and improved until to-day fixation of a movable kidney is one of the most successful surgical operations. A longitudinal incision along the border of the quadratus muscle is sufficient to give access to the organ. The kidney is exposed behind the peritoneal reflection and a strip of the fibrous capsule is removed. Sutures are passed through the parenchyma and the kidney is fastened to the lumbar muscles as high up as possible. The tissue planes are closed by suture, a small drain being left in the wound if desired. The patient should remain in bed at least four weeks. Some surgeons keep the patient in bed for from ten to twelve weeks. This operation is called *nephropexy*, or *nephrorrhaphy*. Its mortality is no more than one per cent. If properly carried out the operation will almost always permanently fix the kidney. It sometimes fails, however, to relieve the symptoms of the patient, which tends to show that many of the symptoms complained of by these patients are not due to the movement of the kidney, but to some other cause. Some surgeons do not regard fixation of a movable kidney as a justifiable operation in most of the cases in which it is performed. For example, Israel says that it is the fashion at present to go to a surgeon to have the kidneys anchored just as it used to be to go to a gynecologist to have the ovaries removed.

Hydronephrosis.—Obstruction to the urinary flow if occurring at any point above the opening of the ureter into the bladder, will cause a cystic dilatation of the kidney. If the urine is aseptic the dilatation is spoken of as hydronephrosis, or uronephrosis. If the urine contains pus the term pyonephrosis is used. Such obstruction may be temporary or permanent; it may be complete or incomplete. Both kidneys may be affected, but complete obstruction on both sides can exist for only a short time without causing death; hence obstruction at the neck of the bladder or in the urethra fails to produce much dilatation of the kidney. If the obstruction is an incomplete or an intermittent one the dilatation will usually be the most marked, since the renal parenchyma is then not entirely destroyed. In the early stages of the trouble the dilated pelvis and calices closely resemble the normal structures. Later, the kidney is changed to a sac with a relatively thin wall, in which may be found microscopically more or less parenchymatous tissue. Even after a hydronephrosis has lasted a long time the remains of the glomeruli and tubules still possess some excretory power, and within a short time after the pressure is relieved this functional activity of the kidney greatly increases. It is a good plan, therefore, in operating upon a long-standing complete obstruction, to wait several days before deciding upon the removal of the affected kidney.

The obstruction which causes the hydronephrosis may be either congenital or acquired. The ureter may be too small, or it may be twisted, or either its upper or lower opening may be faulty, or there may be valves somewhere in its course.

The chief causes of acquired hydronephrosis are found

in the ureter or pelvis of the kidney, although in some instances pressure from outside the ureter, such as that due to parametritis or to a pelvic tumor, may obstruct the flow of urine. The lumen of the ureter may be blocked by inflammation, usually of a gonorrhœal or tuberculous origin. Traumatism, such as a severe contusion of the abdomen, may be followed by hydronephrosis, resulting from the presence of blood clots within the ureter or from extravasation of blood and cicatricial contraction outside of the ureter. Hydronephrosis may develop in a movable kidney after kinking or twisting of the pedicle of the organ. This strangulation is temporary, but is apt to recur, and is associated with some formation of fibrous tissue which tends to increase the obstruction.

The mucous membrane at the origin of the ureter may act as a valve to obstruct the orifice. Such valvular action is more likely to occur if displacement or dilatation of the kidney causes the ureter to arise at an abnormal angle. Swelling of the mucous membrane facilitates this and other forms of obstruction.

A calculus or other foreign body may block the lumen of the ureter and produce hydronephrosis. The symptoms may be violent in case the obstruction is sudden and complete, or so mild as to be scarcely noted if the obstruction is incomplete and very gradual. A tumor will be felt in the lumbar region, the lower portion of it usually lying behind the colon. The hydronephrosis may be so great that the tumor extends as far as the median line, or even into the pelvis. Complete hydronephrosis of short duration gives a tense and exquisitely tender tumor, whereas in a chronic case the tenderness is slight or wanting, and fluctuation is easily made out.

If a hydronephrosis lasts for a long time its fluid loses more and more the characteristics of urine. Spontaneous cure is still possible if the obstruction is relieved, even though this has been complete. With the lapse of years the renal parenchyma may be wholly destroyed, and the sac lose its contents and shrivel up. The hydronephrotic sac may rupture, as the result of traumatism, either into the peritoneal cavity or subcutaneously. Severe and even fatal hemorrhage may follow this accident. The contents of the sac may become infected and the condition change from hydronephrosis to pyonephrosis. Hydronephrosis must be differentiated from cystic tumors not connected with the kidney, such as an echinococcus cyst of the liver, dilated gall-bladder, and ovarian tumors.

The following procedures are recognized to-day as suitable in the treatment of hydronephrosis:

Ureteral catheterization of the pelvis of the kidney followed by irrigation with nitrate-of-silver solution will occasionally cure hydronephrosis.

Retroperitoneal puncture of the sac was formerly the routine treatment. It is still of value as a means of affording temporary relief under circumstances in which a better operation cannot be carried out. It carries with it the risk of infection, for even if the skin and trocar be aseptic the contents of the sac may not be, so that infection may follow the withdrawal of the instrument. Puncture should of course be made in the loin behind the peritoneal reflection.

If hydronephrosis is due to kinking of the ureter in connection with movable kidney, fixation of the organ may prevent its recurrence.

Lumbar nephrotomy will cure many cases of hydronephrosis. If it does not do so the obstruction may be reached and overcome through the sac, or by exposure of the ureter outside of the sac.

If there is a valvular action of the mucous membrane at the mouth of the ureter this may be overcome by a longitudinal incision sutured transversely. Stricture of the ureter may be successfully treated in the same manner. A portion of the sac may be resected.

Ureteral stricture may be dilated by instruments passed through the pelvis of the kidney, or the stricture may be resected, or the ureter may be cut across below the stricture and reimplanted into the pelvis of the kidney.

Under certain circumstances an anastomosis may be established between the sac and the bladder.

If none of these operative measures succeeds in curing the patient, and the opposite kidney can be shown to be functionally capable of doing the work of both, the diseased organ should be extirpated so that the patient may be saved from a persistent urinary fistula and from the evils of a suppuration which is certain to develop in the sac sooner or later if there is a persistent fistula.

The lumbar incision is best suited to the removal of the sac. The peritoneum should not be opened, but freed from its attachment and displaced inward. If it is necessary to evacuate the contents of the sac before removal, the wound made by the trocar should be carefully sutured. The sac will then be smaller and less tense, and its removal will usually not be difficult. The mortality of this operation in recent years is about six per cent.

A hydronephrotic kidney may be removed transperitoneally through an anterior incision. This method permits of an inspection of the other abdominal organs, but it exposes the abdominal cavity to infection from the contents of the sac, and there remains, behind the posterior peritoneum, a large cavity which is sometimes difficult to treat. It has been drained through the lumbar region and also anteriorly by stitching together the anterior and posterior layers of peritoneum around the wicks of gauze used to drain the retroperitoneal space.

Suppuration in the Kidney.—Infection of the kidney may take the form of suppurative pyelitis to which may be added one or many abscesses in the parenchyma. The condition is then spoken of as surgical kidney, or suppurative nephritis. If there is retention of urine and pus the condition is called pyonephrosis. A hydronephrosis may become a pyonephrosis by reason of infection.

Calculi may give rise to suppuration, or they may develop in consequence of alkaline fermentation, which may be due to suppuration. Infection in the kidney may come through the blood or through the ureter. The former is known as hæmatogenous infection, and the latter as urinogenous infection. The kidney is one of the chief avenues for the removal of germs from the body, and it is not surprising that they occasionally lodge and develop in its tissues. The gonococcus is the microbe most frequently found in urinogenous infection. Obstruction to the flow of urine greatly favors the development of bacteria in the kidney.

The symptoms of renal suppuration are varied. The trouble may begin as an acute fever, with chills and great pain and tenderness; or it may develop after a cystitis, or after an injury. If the urine is obstructed the renal tissue will be destroyed with a rapidity far greater than that which takes place in hydronephrosis. Recovery may follow rupture of an abscess into the renal pelvis and the discharge of pus through the ureter; or an abscess may break through into the paranephric tissue and be evacuated externally, cure of the trouble resulting. Such cases, however, are exceptional. Usually the suppuration continues and smaller abscesses fuse and form larger ones until the kidney becomes a pus sac.

Sometimes the symptoms are so well marked that the disease is easily recognized. At other times pyuria will come on gradually and continue for a long time without pain. If the urine suddenly becomes clear, and pain and tenderness develop in the loin, it is probable that obstruction has taken place.

A differential diagnosis of renal pyuria and purulent cystitis can easily be made by irrigating the bladder until the fluid returns clear. After a few moments' rest the bladder should again be irrigated. If the fluid is again purulent, the pus probably comes from the kidney. A more certain diagnosis can be made with the cystoscope.

The best treatment for pyonephrosis is immediate nephrotomy. Care should be taken to drain every abscess, and a probe should be passed through the ureter to the bladder. The kidney should be freely drained. If the destructive process has not gone too far, this treatment will often effect a cure. If the ureter is obstructed, and the obstruction cannot be overcome, and if the other kidney is functionally active, the diseased organ should

be removed. This may be done at the first operation if the kidney is found to be greatly disorganized. But if considerable parenchyma is present it is better not to sacrifice the organ unless the separated urine has been tested and the functional activity of the opposite kidney demonstrated. All surgeons agree that a suppurating kidney should be operated upon through a lumbar incision. The mortality of nephrotomy for renal suppuration is about twenty per cent. The mortality of primary nephrectomy for suppuration is about twenty-five per cent., and that of secondary nephrectomy about sixty per cent.

Some surgeons do not believe in nephrotomy as a treatment of renal suppuration, taking the ground that it rarely cures the patient, and therefore prolongs the course of the disease. The views given above are those of Schede as expressed in the "Handbuch der praktischen Chirurgie" (Ferdinand Enke, 1901).

Paranephritis.—The fatty capsule of the kidney may undergo suppurative inflammation. This condition is known as paranephritis. The suppuration may be due to extension from within the kidney, or to an extension of inflammation from the stomach, liver or gall-bladder, intestine, or one of the vertebræ. It may follow appendicitis or diseases of the pelvic organs, or pus in the pleura may break through the diaphragm and so give rise to paranephritis. It may also follow acute infectious diseases, for the blood-vessels of the fatty capsule are intimately connected with those of the kidney, so that the fatty capsule may become infected without involvement of the kidney itself. Doubtless there are forms of paranephritis which are not suppurative, but their diagnosis can hardly be made, and therefore they may be neglected. When pus is introduced into the fatty capsule it quickly destroys the existing tissue and extends around the kidney. Unless it is evacuated externally the pus increases rapidly in quantity and may reach from the diaphragm to the pelvic brim. As the abdominal wall covering the fatty capsule is quite thin, the presence of pus will soon show itself in œdema and redness of the skin, and the abscess may break spontaneously just above the crest of the ilium or just below the twelfth rib. It may open into the pleural or peritoneal cavity, or into the duodenum, colon, or bladder. It may involve the spleen or liver. The abscess may contain urine mixed with pus.

The symptoms may develop suddenly with chills and fever and great pain, or they may come on slowly, with a lower temperature curve, which has no characteristic form. Until the abscess develops the diagnosis may be obscure; later, it is easily made. There will be a bulging on the affected side, especially when the patient is in a sitting posture. Fluctuation can sometimes be made out.

The abscess should be freely opened by an incision in the lumbar region posteriorly to the peritoneal reflection. This incision may be vertical, transverse, or oblique.

The mortality after operation in uncomplicated cases is about seventeen per cent., while that after operation in complicated cases is about fifty per cent. If the paranephritis is secondary to suppuration of the kidney the mortality after operation is still higher, being nearly fifty-five per cent. Recent statistics show that the danger to the patient is not from the operation, which is comparatively simple, but from the damage to the other organs caused by the suppuration. Upon this will depend the prognosis.

Renal Calculus.—Urinary salts are deposited upon any foreign body which finds its way into any portion of the urinary tract, and this fact explains the formation of some renal calculi. Sometimes the nucleus is very small, made up of merely a few epithelial cells or a clump of microbes. Other nuclei are macroscopic—a piece of catheter, a pin, or a sliver of necrotic bone. Some investigators believe that a foreign body forms the nucleus of every calculus, but whether this be true or not, it is certain that no such nucleus can be demonstrated in a large majority of cases. Others have shown that every calculus contains an organic framework, and have thought thereby to explain their development; but it has been found that every crystal formed in the urine has an organic framework, so this theory of formation of calculi seems insufficient. Still others have based a theory upon the fact that the composition of urine varies a good deal at different periods of the day. They have supposed that crystals form in the kidney when the urine is concentrated, that these are dissolved by subsequent dilute urine, and that a failure of the urine to redissolve such crystals is the starting-point for the formation of a calculus.

While the exciting cause of a calculus cannot be given in many instances, certain predisposing causes are well known. Thus, if the urine is constantly overladen with uric acid and its salts, as, for example, in gout, the formation of renal calculi is facilitated. After severe spinal injuries renal calculi form with great frequency, due perhaps to the development of bacteria in the urinary tracts of such patients.

Calculi are far more common in certain countries than in others. They occur more often in childhood and after the fortieth year than in early adult life. Their relative frequency in males and females is about 20 to 1, a discrepancy which is only partly accounted for by the ease with which a small stone may pass through the female urethra. Various articles of food and drink have been thought to favor the development of calculi, but the testimony upon this point is not very convincing.

Renal calculi are given different names, according to their size. If very small, they are spoken of as sand; if as large as the head of a pin, they are called gravel; while larger calculi are spoken of as stones. Some calculi will form only in acid urine, and others only in alkaline urine.

Nearly all calculi may be classified, according to the substances of which they are composed, into three groups: (1) uric acid and urates; (2) calcic oxalates; (3) calcium and triple phosphates. There are a few rare instances of the occurrence of calculi composed of calcium carbonate, cystin, xanthin, indigo, or some other substance. A calculus may be composed of one substance throughout, or it may be made up of layers of different substances indicating different conditions which existed during its formation. Thus, a calculus may have a centre composed of uric acid, covered by a layer of calcium oxalate and an outside layer of triple phosphate (Fig. 3081, *c*).

The commonest renal calculus is one composed of uric acid, either alone or mixed with urates. If pure it is of a pale yellow or reddish or brownish color, and has a smooth or granular surface. It is very hard and has a specific gravity of about 1.5. Its cut section shows a concentric arrangement. It develops in acid urine.

A calculus of calcic oxalate is usually small. It is yellowish or reddish, or brown or black from the presence of blood pigment. It is very hard and its surface is covered with small spines. On cut section there will be seen a concentric arrangement of wavy lines. It develops in acid urine.

A triple phosphate calculus is composed of ammonio-magnesium phosphate or calcic phosphate. It has a smooth or slightly granular surface of white or gray color, and on cut section appears amorphous or lamellated. Such a calculus has a low specific gravity. It develops in alkaline urine. It is usually single and may grow to a very great size.

The shape of a calculus is due in great measure to the situation in which it develops. Thus, a single calculus is rounded, and if formed in a tubule or in a calyx it will be shaped something like a pea or a bean. If formed in the pelvis of the kidney it may be much larger and may show prolongations corresponding to the calices (Fig. 3077). If two or more calculi are found in the same cavity their surfaces will be facetted where they have lain in contact with each other.

Necrotic tissue may become incrusted with urinary salts while such tissue is still attached to the body.

This incrustation is more apt to occur if secondary infection has taken place and the urine has become alkaline.

Every calculus exercises a deleterious influence in its neighborhood, but its action may be slight so long as the urine is normally acid. If infection occurs and sets up alkaline fermentation of the urine, the destruction of the

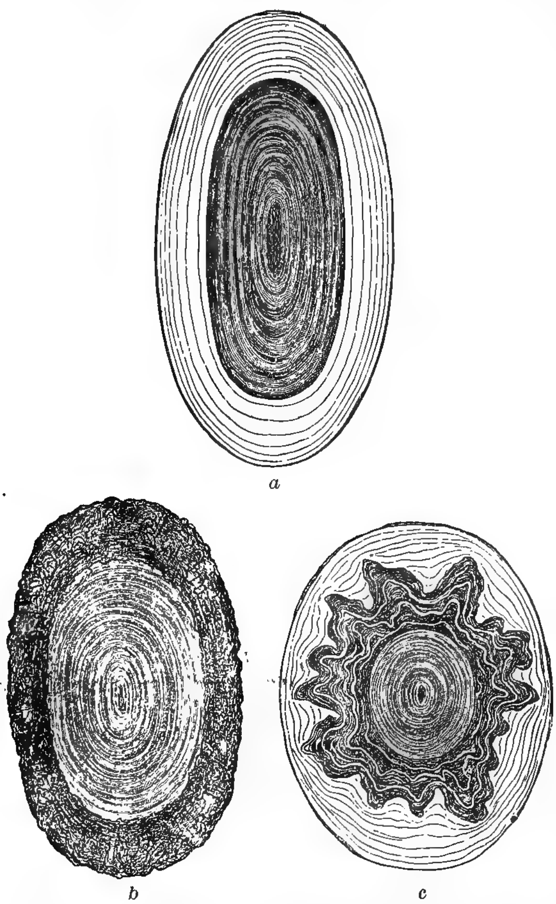


FIG. 3081.—Urinary Calculi. *a*, Centre of uric acid, outer covering of phosphates; *b*, centre of uric acid and outer covering of calcic oxalate; *c*, calculus of uric acid, calcic oxalate, and phosphates. (From Sonnenburg.)

parenchymatous tissue and the formation of new fibrous tissue will go on much more rapidly. Therefore, if the case is of long standing the kidney may atrophy and shrink to a small fibrous sac around the calculus. Or there may be produced chronic interstitial nephritis without much change in the size of the organ. The calculus may obstruct the flow of urine and lead to hydronephrosis or, more often, pyonephrosis, with more or less destruction of the renal parenchyma. The kidney may then contain numerous abscesses connected with one another and in many of which there may be calculi. This alkaline fermentation of the urine of course stops the deposition of crystals of uric acid or calcic oxalate, but it does not stop the growth of a calculus already formed of one of these substances. Indeed the size of this stone may increase more rapidly than before, but the new layers deposited will be made up of phosphates (Fig. 3081, *a* and *c*).

One of the risks of allowing a renal calculus to remain untreated is the danger to the second kidney. Some observers state that calculi exist in both kidneys in fifty per cent. of the cases of renal calculus. If infection is added to the calculus, the risk of injury to the second kidney is much greater. The ureter on the infected side, and also the bladder, will speedily become contaminated, and there is a grave risk that the infection will travel up the opposite ureter.

A renal calculus usually causes symptoms which are unmistakable, although no single subjective symptom can be spoken of as pathognomonic; but the diagnosis can be made absolutely if the stone is so large that it can be palpated, or if palpation produces a creaking or grating as one stone is rubbed upon another. In exceptional instances a probe passed through the ureter may demonstrate the existence of a renal calculus in the kidney. Furthermore, radiography may be looked upon as an absolute method of diagnosis if the picture shows clearly the outline of the stone. Its failure to do so does not always disprove the existence of the stone, since some calculi, notably those composed of uric acid, are so easily penetrated by the *x*-ray that a good deal of practice and just the right kind of apparatus are necessary in order to differentiate such concretions from the surrounding tissues (Fig. 3077).

The symptoms usually depended upon for making a diagnosis of renal calculus are pain, hæmaturia, presence of gravel or sand in the urine, enlargement of the kidney, attacks of anuria, and vesical irritation. The presence of one or more of these symptoms is more significant if the patient is of a gouty or rheumatic diathesis and is in the habit of passing urine containing an excess of uric acid and urates, and from which these salts are easily precipitated. The diagnosis is still further strengthened if the patient gives a history of attacks of colic, or of long-continued, dull pain in the lumbar region, increased by jars and muscular exertion. If a stone is unaccompanied by inflammation and does not obstruct the flow of urine, it may cause little or no real pain. Furthermore, a kidney in this condition will not be especially sensitive. If a small stone becomes loosened and enters the ureter intense pain will be caused in the lumbar region. This pain will often radiate along the ureter into the bladder or into the testicle or the head of the penis or down the thigh. It may also extend upward, or throughout the abdomen. The pain may be so intense that the patient is collapsed and wet with perspiration, and consciousness may be lost.

There is usually violent vesical tenesmus with the passage of a few drops of dark urine which possibly contains blood; or, if the calculus obstructs the flow of water from the affected kidney while that from the other continues, the urine passed may be normal. Such an attack accompanies the passage of a stone through the ureter and subsides when it enters the bladder. The attack may also be due to any acute congestion or to venous distention, or to obstruction of the urine, however caused.

The hemorrhage which accompanies a renal calculus may be so slight that it is recognized only upon microscopical examination. Such examination should be made daily in suspected cases, since the constant presence of a few red blood corpuscles in the sediment is one of the best signs of renal calculus. The amount of blood may also be much greater, and, in rare instances, the hemorrhage may even threaten the patient's life.

Increase in the size of the kidney is not an infallible sign of calculus, for the organ is not always enlarged by a calculus, and it may be enlarged as the result of tuberculosis, tumor, or obstruction to the escape of urine, however caused.

The anuria which often occurs in cases of renal calculus is of reflex origin. It is most frequently seen in connection with the attacks of renal colic which accompany the passage of a stone through the ureter, or which are due to obstruction to the flow of urine or blood from the kidney, caused in some other manner, or to injury of the kidney. There is also an hysterical anuria. Reflex anuria usually passes off as soon as the acute attack is over and is generally followed by a temporary polyuria.

The symptoms of vesical irritation accompanying renal calculus, such as urgency and frequency of micturition and pain in the urethra at the close of the act, are so

similar to those caused by cystitis that a cystoscopic examination is often required to differentiate between the two.

In case of a renal calculus the mucous membrane of the bladder will not appear inflamed. If the mouth of the ureter is brought into view, the surgeon may observe the discharge from it of cloudy, purulent, or bloody urine. Pressure on the affected kidney will increase the flow of pus, unless the ureter is blocked. In that case no urine will flow from it into the bladder. The discharge of pus from the ureter does not prove that the renal suppuration is due to calculus, though this is one of the commonest causes of pyelitis. A diagnosis of tuberculosis may be eliminated by a bacteriological examination of the urine which should be drawn for the purpose through a catheter in order to avoid contamination with the smegma bacillus.

Attempts to dissolve formed calculi by means of internal medication of whatever nature are wholly unsuccessful. Internal medication must not on this account be regarded as useless, since dilution of the urine lessens the danger of further precipitation and the increased flow may also wash out small calculi already formed. Furthermore, bacterial action can often be prevented or lessened by the internal use of such urinary antiseptics as boric acid, salol, benzoates, urotropin, etc. Glycerin in quantities of two or three ounces at a single dose sometimes has a good effect in lubricating the urinary passages and bringing away a great quantity of calculi and sand. A part of this good result is doubtless due to the great quantity of water which the patient drinks to relieve the thirst caused by the glycerin.

The removal of a renal calculus through a lumbar incision is the correct method of dealing with this trouble. The incision in the kidney should be through the cortex rather than directly into the pelvis, since the former method facilitates the operation and gives better drainage, if drainage is necessary. Operation may be regarded as immediately necessary if anuria has lasted for two days, or if there is complete obstruction of the ureter or dangerous hemorrhage, or if the calculus has already set up suppuration. In the last-mentioned condition there is no hope that a spontaneous cure will take place, while the longer the operation is delayed the more extensive will be the destruction of the kidney. Even if the course of the trouble is aseptic it is better not to wait, since one has no means of knowing how soon infection may occur. The mortality after operation for stone in aseptic cases is less than six per cent., while in septic cases it is four times as great.

Before the kidney is opened it should be freed from its fatty capsule, after which an elastic ligature can be passed around the vessels of the pedicle. This will control hemorrhage until the exploration of the kidney is finished. The kidney should be opened along its convex border a little posterior to the line of incision employed at autopsy (see Fig. 3075). The incision should not be carried into the poles. Through this incision the pelvis and calices may be explored and all calculi removed. A probe should be passed into the ureter to demonstrate that its lumen is free as far as the bladder, or to reveal the cause and situation of any obstruction which exists. This must be overcome, even if it is necessary to prolong the lumbar incision downward and forward. A calculus situated high up in the ureter may be pushed back into the renal pelvis and thus removed, or it may be pushed into the bladder. If it cannot be removed in any other way the ureter should be incised upon it and again sutured after the extraction of the stone.

If there is an abscess in the kidney or pus in its pelvis the wound in the kidney should be drained; otherwise it may be sutured. When reflex anuria is present, however, most surgeons prefer to leave a drain in the renal incision, even though there is no pus.

Primary nephrectomy for renal calculus is an operation seldom performed, since the condition of the kidney will rapidly improve after nephrotomy. If the parenchymatous tissue of the kidney has been entirely destroyed, or if its suppurative condition is such that it is a source of danger to the patient, it may be better to remove it than to drain it.

Essential Renal Hemorrhage and Nephralgia.—Hemorrhage from the kidney sometimes occurs without any such obvious cause as traumatism, calculus, tuberculosis, new growth, or the congestion which follows the sudden relief of retained urine. In tropical countries hemorrhage frequently follows infection by distomum, filaria, and other parasites. There is also an inflammatory hemorrhage from the kidney, but this is usually microscopic in character. Apart from all these causes hemorrhage may occur with or without renal colic. The kidney has several times been opened under such circumstances and nothing to account for the hemorrhage has been found. Some of these patients were true hæmophiliacs, giving a history of severe hemorrhage following slight traumatisms in other portions of the body. But there is also a true angioneurotic hemorrhage which on account of its severity or the pain which accompanies it, may require operation. In some instances rest, a milk diet, and the administration of medicines to favor blood clot, have effected a cure. If the hemorrhage continues nephrotomy should be performed. This may reveal a possible cause for the hemorrhage, for such a beginning tuberculosis, for the presence of an abscess or a calculus, or for the retention of urine. This operation will usually cure either an active or a passive congestion. There is no object in removing a kidney if no apparent cause of the hemorrhage can be found, unless, in the case of a hæmophiliac patient, hemorrhage from the incised organ makes it necessary to ligate the renal vessels in order to save life. The wound in the kidney should be drained and allowed to granulate.

Nephrotomy has recently been performed with success for the cure of unilateral renal pain in cases of nephritis when there is reason to suppose that the inflammation affects only one kidney. Splitting of the capsule has been advised for the cure of interstitial nephritis whether unilateral or bilateral. Its success under such circumstances is still problematical. It is based on the theory that the contraction of the capsule destroys the parenchymatous tissue, and that if the tension is relieved by incising or removing the capsule, the progress of the disease will be stopped and even lost ground may be regained.

Aneurism.—An aneurism of the renal artery is of rare occurrence. It may follow traumatism or develop spontaneously. In the former case it is likely to be associated with hæmaturia. It may exist for a long time without symptoms. The symptoms other than hæmaturia which have been noted are the presence of a tumor only slightly movable, smooth, and semi-fluctuating. Such a tumor does not give a feeling of pulsation nor a bruit. The aneurism may give rise to a sense of pressure, or to attacks of pain which are so severe that they have been mistaken for biliary colic. If the aneurism continues to grow it may terminate life by bursting retroperitoneally or into the peritoneum, or into the renal pelvis. If it ruptures into the renal pelvis a prompt nephrectomy may save the life of the patient. There are records of three successful operations for renal aneurism.

Syphilis.—Syphilitic gummata may develop in the cortex or in the pyramids of the kidney. In the early stage these gummata have a soft yellowish centre of caseation around which is a zone of connective tissue and strangulated tubules, and still outside of this a zone of active growth with infiltration of small round cells. There is also a diffuse form of syphilis of the kidney in which the organ presents the appearance of the "large white kidney." In either form the syphilitic kidney may involve the surrounding tissues in the inflammation and give rise to a dense tumor which may easily be mistaken for malignant disease. Such a tumor may soften in spots and discharge necrotic masses through sinuses in the skin. The proper treatment is the internal administration of antisyphilitic remedies.

Cystic Tumors.—Three kinds of cysts may form with-

in the kidney and require surgical treatment. They are solitary cysts, the tumors of polycystic degeneration, and echinococcus. The solitary renal cyst is a benign trouble and can do injury only by pressure, in case it reaches a large size. Such a cyst contains clear serous or cloudy fluid, possibly stained with blood pigment. Large cysts of this kind are rare. They arise in the cortex and are probably due to retention beginning in a glomerulus or in a tubule. The cyst may be strictly solitary, or two or more may coexist. Their situation is usually along the convex border, or in the lower pole of the kidney. In only a few instances has operation been performed for this trouble. If an operation is undertaken, the cyst should be extirpated and the renal parenchyma sutured; or, if complete suture is impossible, the cavity may be drained.

Polycystic degeneration is a serious and usually fatal disorder which may affect the kidneys either before or after birth. The etiology is still obscure. Schede affirms that there are two forms of polycystic degeneration. In one form overgrowth of the interstitial tissue obstructs and strangulates the tubules and thus leads to the development of multiple cysts. In the other form the epithelium, especially of the tubules, undergoes proliferation and subsequent degeneration, so that the condition may properly be called adenocystoma.

Congenital polycystic degeneration is usually bilateral; and since it causes a speedy death it has little surgical interest. The polycystic degeneration of later life is sometimes unilateral, so that occasionally incision of the cysts, nephrotomy, or even nephrectomy might be of benefit. Before the kidney is removed the functional capacity of the other kidney should be definitely determined.

The natural course of polycystic degeneration is the destruction of the renal tissue. It is often associated with the formation of multiple cysts in the liver, and is frequently accompanied by arteriosclerosis and cardiac hypertrophy. Therefore death is usually not long delayed. Still there are instances in which a patient has lived ten years after such a cystic renal tumor was palpable.

The diagnosis of polycystic renal degeneration is difficult. The enlarged kidney will probably be mistaken for malignant disease. It is sometimes possible to feel the pebbly surface of the organ and in rare instances to make out fluctuation in the larger cysts. Cachexia may be absent for a long time.

Echinococcus may develop in the kidney, giving rise to a single smooth cyst which may feel as hard as a fibroma, or may yield an indefinite fluctuation or the peculiar thrill found in echinococcus cysts elsewhere. If the cyst bursts into the renal pelvis, hooks or daughter cysts may be found in the urine. Such cysts, as far as known, are always single. As the renal tissue is unaffected except by reason of pressure, the kidney should not be removed. The cyst, whether suppurating or not, should be incised, sutured into the abdominal wound, and drained.

Suprarenal Gland.—While little is known of the physiology and pathology of the suprarenal gland, it is usually found diseased in connection with a group of symptoms described by Addison, and which are therefore known as Addison's disease. The affection of the suprarenal gland under such circumstances is almost always tuberculous. The bronzing of the skin which is generally supposed to be characteristic of Addison's disease does not exist in about one-sixth of the cases in which the suprarenals are diseased, and it is present sometimes when the suprarenals are apparently normal. Some hold the view that Addison's disease is an affection of the sympathetic ganglion which lies near the suprarenal body, and that the gland is involved only as the lesion spreads. There are some cases which seem to show that the early removal of the tuberculous suprarenal may benefit the patient, since the disease may for a time be unilateral. In some of the few cases which have been operated upon, the suprarenal gland and kidney were so intimately adherent that it was found necessary to remove both. Benign tumors, encapsulated hæmatomata, and malignant tumors, of the suprarenal gland, are pathological rarities which a surgeon may be called upon to treat. It is not likely that a differential diagnosis can be made between a tumor of the suprarenal gland and one of the upper pole of the kidney. This point is not of much importance, however, since practically the same operation is required for the two conditions, and very likely both organs will have to be removed together. The gland may be reached through a lumbar or an abdominal incision. If the former is chosen, it will need to be large, and should extend well upward.

Edward Milton Foote.

KINO.—"The inspissated juice of *Pterocarpus Marsupium* Roxb. (fam. *Leguminosæ*)," U. S. P. Many substances, from different parts of the earth and different plants, have, at one time or another, appeared under this name. That which is in the market at present is chiefly the product of various species of *Eucalyptus*, the official article being very scarce and dear. Very recently, however, it has been reported that extensive new districts have been opened up, capable of yielding any required amount of official kino at a low price. The plant yielding the latter is a large, handsome Indian tree, whose wood is also valued for timber. In common with other species of *Pterocarpus*, this tree contains a bright-red juice, which exudes upon incisions being made in the trunk, and hardens, upon evaporation and drying, into dark, reddish-brown, brittle tears.

This, the East Indian (Malabar) kino, has been imported since the beginning of the present century, and for medical purposes has superseded the African and other varieties which were then used. It always comes in fragments or angular pieces, generally not larger than split peas, and oftener considerably smaller; occasionally these fragments cohere together in crumbly lumps. Kino is of resinous lustre and fracture, very brittle, its pieces are smooth and shining, opaque, except at their edges, where they are ruby-red and transparent; general color dark reddish-brown, sometimes almost black; odor, none; taste very astringent and sweetish. The saliva is colored bright red when kino is chewed. It is partially soluble in cold water, wholly so in boiling water and in alcohol, not in ether.

Kino is a homogeneous uncrystallizable substance, related to the tannic acids of cinchona and krameria, and more closely to catechu. Its deep red solution becomes violet on addition of a proto-, and dirty green with a persalt of iron. It appears to consist principally of *kinotannic acid*, a red, transparent substance, soluble in alcohol and water, and capable of decomposing upon long standing in watery solution into insoluble *kino-red; kinoïn* and *catechin* may be obtained from it in small quantity, and *pyrogallic* acid, by distillation and other means.

Action and Use.—Kino is an active astringent of the logwood and catechu kind, and is employed for exactly the same purposes. For subacute or chronic diarrhœa or dysentery it is equally good with other astringents, and less unpleasant than many of them. As a local application or injection, *tannic acid* is to be preferred. Kino can be given in substance, if desired—dose, 1 gm. (1 gm. = gr. xv.) or in aqueous infusion; as the latter is apt to gelatinize, it should be made freshly. The official tincture (*Tinctura Kino*, U. S. P.; strength $\frac{1}{10}$, with fifteen parts of glycerin) keeps better, and is the most generally useful form, but this also shows a strong tendency to gelatinize after a time.

W. P. Bolles.

KISSINGEN.—Kissingen, one of the most important and best known of the German spas, is a town of 4,306 inhabitants, beautifully situated in the valley of the Saale in Bavaria, about sixty miles from Frankfort-on-the-Main. It is 554 miles from Paris viâ Frankfort and Würzburg, and can be reached from the former city in eighteen hours. It is about six hundred feet above sea-level, and is surrounded by wooded hills affording opportunity for the "Terrain-Cur." In the circular valley in

which it is situated are extended pleasure grounds and promenades. The climate is mild, although there is considerable rain. The mean yearly temperature is 45.1° F. and the mean monthly is: May, 54.8° F.; June, 60.2° F.; July, 62.7° F.; August, 60.4° F.; September, 54.3° F. The yearly rainfall is 25.3 inches.

The season extends from May 1st to October 1st, and during this time a large number of visitors frequent this spa; in 1899, the number was 19,416, the majority of which were Germans. The accommodations are excellent and sufficient for three or four thousand persons. The drinking-water is from well source, but said to be good, and the drainage is efficient. The springs are cold saline, the principal constituents being chloride of sodium, ferrous carbonate, sulphate of magnesia, carbonate of calcium, and free carbonic acid. Three of the springs: the Rakoczy, Pandur, and Maxbrunnen are situated in the town, and two, the Schönbornsprudel and the Sool- or Salinensprudel, a short distance beyond the town limits. The Rakoczy, Pandur, and Maxbrunnen are used for drinking, and the Soolsprudel and Pandur are the ones principally used for baths.

The following is the analysis (from Eulenburg) of the five springs:

Number of Grams of Solid Constituents in Each Litre of Water.

	Rakoczy.	Pandur.	Max-brunnen.	Sool-sprudel.	Schönborn-sprudel.
Sodium chloride	5.822	5.207	2.316	10.554	11.719
Calcium chloride	.286	.241	.376	.250	....
Lithium chloride	.020	.016	.007	.020	.024
Magnesium chloride	.303	.211	.108	.330	....
Magnesium sulphate	.588	.597	.200	.904	1.472
Calcium sulphate	.389	6.300	.190	.856	.332
Calcium carbonate	1.061	1.014	.565	1.304	1.855
Ferrous carbonate	.031	.027	.002	.030	.019
Calcium phosphate	.005	.005	.005	.004	.007
Sodium nitrate	.009	.005	.077	....	....
Sodium bromide	.008	.007	Trace.	.009	.011
Silicic acid	.012	.004	.003	.001	.013
Organic matter, etc	.022	.362	.064	.037	.395
Total solids	8.556	7.996	3.913	14.299	15.847

There are three bath establishments, the property of the Government: (*a*) the Kurhaus with forty bathrooms; (*b*) the Saline with one hundred bathrooms: (*c*) the formerly called "Actienbad" with one hundred and twenty bathrooms. For bathing purposes the waters of the Sool- or the Schönbornsprudel are often rendered more stimulating by the addition of the mother liquor remaining after the extraction of the sodium chloride at the salt works. There are also carbonic-acid gas baths, mud baths, inhalation rooms, douches, massage, and a medico-mechanic institute. There are also private sanatoria for the treatment of various diseases. The Rakoczy is the best-known spring, and over four hundred thousand bottles of this water are sent abroad every year. The usual time for drinking the waters is before breakfast, from seven to nine. From two to six glasses are drunk, a fifteen minutes' walk being taken after each glass.

Kissingen waters are recommended for a variety of maladies: Hemorrhoidal troubles, constipation, catarrhal conditions of the stomach and bowels, gouty and rheumatic affections, uric-acid diathesis, bronchitis, anæmia, scrofula, amenorrhœa, functional nervous disorders, glycosuria, obesity, malaria, neuralgia, the headache from dysmenorrhœa, cardiac diseases, and some chronic skin affections. According to Dr. Thomas More Madden, "the mother lye or concentrated saline water of the Soolensprudel, is applied with wonderful results as a local application to scrofulous glandular swellings and similar affections."

It is well to advise the visitor that here as at all other spas, the waters and baths should be used only under the direction of one of the local physicians, as otherwise harm instead of benefit might ensue. It is not only the use of the waters, but quite as much the carefully arranged daily plan of life as to diet, rest, exercise, etc., which produces favorable results.

Edward O. Otis.

KLAMATH HOT SPRINGS.—Siskiyou County, California.

Location.—These springs are located on the Shasta Division of the Southern Pacific Railroad, some eighteen miles from Ager. The resort is 2,700 feet above the sea-level, and is surrounded by a wild and picturesque country with snow-capped mountain peaks and hills clad in evergreen forests. There are ample accommodations for invalids and guests, as well as excellent bathing facilities. The waters are alkaline, saline, and sulphurous. Some of them are carbonated. The springs have already gained considerable celebrity in the treatment of chronic rheumatism, gout, synovitis, chronic cutaneous diseases, dyspepsia, etc.

James K. Crook.

KNEE-JERK. (PHYSIOLOGICAL.)—This term is used to indicate a perfectly normal physiological contraction of certain extensor muscles of the upper leg in response to a blow upon the *ligamentum patellæ* ("tendon tap"), the reply resembling a jerky kick.

From the first there has been a diversity of opinion as to the nature of the phenomenon and this has led to the use of a great variety of synonyms, as: Knee-jerk (K.J., Kj.), knee-kick, knee phenomenon, knee-reflex, patellar (tendon) reflex (Pa.R.), Patellar (tendon) phenomenon, Westphal's symptom, myotatic contraction (Gowers), and their equivalents in other languages.

Similar responses are obtained by striking other tendons, possibly any tendon. The knee-jerk is merely the best studied and most convenient member of a large group of tendon reflexes or phenomena. There are also periosteal reflexes and "muscle jerks" of a very similar character but held by many to have a different origin.

It seems strange that a phenomenon of such simplicity remained so long unnoticed. Nowadays even children play with it, but there is no clear mention of the subject in medical literature before the articles of Erb and Westphal which appeared together in the *Archiv für Psychiatrie* in 1875. Westphal speaks of the jerk as known to many laymen "as a curiosity" and admits that his attention was drawn to it by a patient. Guérin, as early as 1856, had mentioned a contraction of tendons, but he does not seem to have had the knee-jerk in mind. As these first articles laid stress upon the diagnostic importance of the subject with reference to pathological conditions of the spinal cord, the keenest interest was at once manifested and an enormous literature began to grow.

For the demonstration of the knee-jerk a very light blow upon the ligament suffices. Such a blow may be given with any thin and relatively firm body (percussion hammer, stethoscope, back of a thin book, ulnar border of extended fingers, etc.) and is commonly effective even when the knee is covered by a moderate amount of clothing. The knee should be flexed so as to put the extensor muscles in a condition of slight tension. For ordinary examinations this is accomplished by crossing the legs, by sitting on the edge of a table with the knee resting on a cushion, or even by letting the leg hang from the arm by which it is lifted from the bed. In more careful studies it is necessary to use special devices to counterbalance the weight of the leg. The tendon tap is followed immediately by a swelling of the *m. quadriceps femoris*, easily seen or felt, and a partial extension of the lower leg. The blow itself may be barely perceived, particularly when the attention is diverted. The sensation of the "jerk" is curiously vague and remote; when the movement is more brisk there is a consciousness of the moving mass but with no feeling of a corresponding effort.

The first investigators of the phenomenon, while recognizing that it was abrogated by certain pathological conditions of the cord, were not quite clear as to its constancy in health. Later and more refined studies justify

the conclusion that the knee-jerk is a perfectly physiological act, but subject to very marked variations; its absence may be assumed only after a careful and repeated examination.

Thus Eulenburg (1878) found no Kj. in about 4 per cent. of the 204 young children examined, and in 5 per cent. of his adult cases; Berger (1879) reported 22 failures in a series of 1,409, 900 of them being young soldiers, or 1.56 per cent.; Bloch's studies of 694 school children resulted in 0.72 per cent. of failures which, however, may be justly corrected to about 0.3 per cent.; Pelizaeus (1883) examined 2,403 boys (nine to thirteen years) with but one failure, or 0.04 per cent., and this boy had a knee-jerk when examined more carefully a couple of years later; Jendrássik (1885) could demonstrate the jerk in all but one of 1,000 persons examined, and this one was found to have diabetes, a disease which often causes the Kj. to disappear; Ferguson (1892) noted no absence in 200 cases examined for life insurance.

The blow on the patellar tendon sometimes causes other muscular responses. Many observers have noted a genuine "crossed knee-jerk," a simple extension of the knee of the opposite leg. This is seen in animals and occasionally in man but probably only under pathological conditions.

A closely related phenomenon, for which the same name is often used, is a crossed "in-knee-jerk" or "contralateral adductor reflex." It is by no means clear that this is really a different phenomenon, although the distinction is insisted upon by Hinsdale and Taylor. These observers found it in from twenty to thirty per cent. of the cases coming to the clinic for nervous diseases. It was not caused by a jarring of the pelvis, although, according to Russell (1896), it as well as a genuine crossed knee-jerk may be produced by a blow on the distal end of the femur or the proximal end of the tibia. A "Pseudokniephänomen" was described by Westphal (1882) as produced by pinching a fold of skin over the tendon or elsewhere on the leg, or by blows of a percussion hammer on the inner condyle, and consisting of a contraction of the quadriceps which comes on slowly. Certain variations of the Kj. have been called "paradoxical." By this is meant sometimes a preponderating action of the flexor muscles (*e.g.*, Benedict, 1889), sometimes the participation of various muscles of the lower leg (*e.g.*, Eichhorst, 1892). The knee-jerk must not be confounded with the "patella clonus," a clonic contraction of the quadriceps when stretched by a quick pull of the firmly grasped patella and said not to occur in health. Remak (1893) has described a presumably pathological "femoral reflex" produced by a skin stimulation in the region of the median border of the *rectus femoris* and involving the quadriceps along with many muscles of the lower leg. Exaggerated "irradiation" of the knee-jerk, so as to cause violent contractions of both legs and even to involve the arms, belongs to the realm of pathology as do many of the less extreme modifications of the phenomenon.

For more exact study of the knee-jerk a great variety of devices have been suggested. The effort was made to construct forms of apparatus for the precise regulation of the force of the tendon tap, and also for the measurement of the extent of the resulting movement. The first form of hammer for giving a definite blow was that of Franck (1880), a spring regulating the force. Other devices with springs were used by Jarisch and Schiff (1882), Danillo (1882), Duprat (1886), Bowditch (with a particularly useful splint to fix the hammer in place, 1888), M. Sternberg (1891), the latest form being that of Castex (1901) with a graduation in terms of gramme-centimetres. The most notable use in careful work of a hammer whose blow is determined by gravity is that of Lombard (1887). Less good is the method of Sommer. In general it may be said that the chief advantage of these complicated hammers lies rather in the uniformity of the blow than in any significance attachable to the force of the blow itself. No definite relation is known between the strength of blow and the size of the kick. Castex has recently tried to determine a sort of "normal" value which he finds to be 130 gramme-centimetres for a surface of one square centimetre. It is quite permissible to be sceptical in this matter.

Devices for recognizing the extent of the movement have been proposed by several observers. Such are the more complicated "Anacomptomètre clinique" of Duprat (1886) and the simpler instruments of Lombard (1888, figured by Mitchell), Mitchell (1888), and Haynes (1899). The first use of a record produced by a simple attachment to mark on smoked paper seems to have been made by Lombard (1887); the method was afterward much refined by Bowditch (1888, 1890) and has been used by some other investigators. Unnecessarily complex is the "Reflexmultiplicator" of Sommer (1894), and the "Reflexograph" of von Bechterew (1892) has no obvious advantage. Such records are of course essential to any extended comparison of the jerks under varying conditions. It is very difficult to form an opinion as to the exact angular size of the jerk. The mean arc of swing is said to be 24° to 25°, with a range from 11° to 48°; there are, however, few measurements of this particular character in which the weight of the leg was properly counterbalanced, to make the pull of the muscle uniform. Lombard (1887) was the first to show that, by use of the recumbent attitude and suspension of the lower leg by a cord, the variation in weight of the lower leg could be eliminated.

While there can be no question that the knee-jerk is a physiological act, it is subject to very considerable variations even in perfect health. It is present in the new-born during the first days of life and has been demonstrated in persons who were over eighty or even ninety years old. It seems to be less vigorous in the very old, and this may be a result of senility, analogous to its disappearance in the last stages of fatal sickness, but such cases deserve a more careful examination with refined methods.

The phenomenon vanishes in sleep. This was first noticed by Rosenbach (1880) in observations in children, but he considered his results uncertain except for deep sleep. Lombard (1887) noted a diminution of the response "when quiet or even a condition resembling sleep had crept on," but he does not seem to have reported its complete absence in sleep. In the Bowditch experiments (1890) it was incidentally demonstrated on some eight or nine different occasions that the response not only grows less as the subject becomes drowsy but actually disappears as the sleep becomes profound, a condition for which there is of course no satisfactory criterion. Noyes (1892) found the influence of sleep particularly easy of demonstration in a case of terminal dementia. According to Ferguson (1893) sleep causes an increase of the jerk as it comes on, but a diminution or complete abolition when deep. It should be noted, however, that Applegarth does not seem to have observed a disappearance of the phenomenon in sleeping dogs.

Mitchell and Lewis (1886) noted that the kick is less good in the evening than early in the day, and this has been amply confirmed by Lombard to whom we owe extended and careful studies of the diurnal variation in man. Fatigue, bodily or mental, has on the whole a depressing influence, but Sternberg (1887) found that extreme fatigue caused an exaggeration. The taking of food causes the average of a considerable series of kicks to be greater than it was before the meal. No one, I think, has studied the influence of hunger or prolonged abstinence.

There is some reason to suppose that the knee-jerk is affected by the weather. Weir Mitchell and Lewis, I believe, first called attention to the lessened response "on dull damp warm days." Lombard compared his two long series (each of fourteen days with seven to nine groups of observations on each day) with the weather record of the same place. In general the curves seem to show that the jerk becomes larger as the thermometer falls but grows smaller as it rises, while it rises and falls with the barometer. The influence of the humidity, wind, etc., was not well defined; in fact the weather

conditions did not vary enough during these series to make the comparison altogether satisfactory.

In the latter part of pregnancy, also a physiological state, the knee-jerk is often increased; at least, Neumann (1895) says he found it so in many of the five hundred women he examined. The exaggeration is still more marked in parturition and particularly in the last stages of the birth act, when too the other reflexes are frequently more vigorous. In the puerperium there is a gradual return to the normal kick. All this is attributed to an increased irritability of the nervous system, but, as we shall see, other causes may be in play.

The research of Noyes in a case of dementia showed a sort of rhythm in the jerk analogous to the variations of the vascular system. This very interesting lead has never been followed out.

In 1883 Jendrássik reported a discovery which completely revolutionized the study of the knee-jerk and whose significance is not yet fully understood. He noticed that the innervation of the sciatic nerve favored the production of the jerk, which is directly dependent upon the crural nerve, and was led to inquire whether other motor impulses had a similar effect. He found in general that the innervation of all motor nerves increased the reflex twitch of the quadriceps and recommended that the subject should lift a weight with one or both hands or simply strongly contract his muscles. The influence of the sensory nerves he found harder to determine but expressed the opinion that their innervation also increased the reflex. At once investigators began to use this method and soon no examination of the knee-jerk was considered complete in which the method of Jendrássik had not been employed to produce a "Bahnung" particularly in case of feeble responses; "faire le Jendrássik" says a recent author.

This inquiry does not seem to have been pursued by Jendrássik, but in 1886 Mitchell and Lewis printed observations which materially extended our knowledge of the ways of enhancing the knee-jerk. These authors called such procedures "reinforcements," a term which is fairly the equivalent of Exner's "Bahnung." It was shown that not merely the relatively violent movements recommended by Jendrássik but all voluntary movements, even when very slight (as winking, deglutition, phonation, voluntary respiratory movements), may suffice to make the coincident knee-jerk bigger. So general is this that we may say that the voluntary innervation of any muscle or group of muscles, except those immediately concerned in the jerk, acts as a reinforcement. And even for the crural nerve it was found that its milder innervation is effective while its vigorous innervation has an inhibitive action and stops the jerk. Mitchell and Lewis were also able to demonstrate that sensory stimulation has far greater importance as a reinforcement than the vague results of Jendrássik suggest. While mere touch is not usually sufficient, pain (pulling hair, needle prick, skin pinch) makes a very good reinforcement. Electrical stimulation, particularly with the wire brush, has a powerful action. Heat and cold are less certain but sometimes very efficient. A bright light (flashes of burning magnesium wire) reinforces as it becomes painful. Experiments with taste gave negative results; hearing and smell were not tested. Galvanism of the head, in the frontal region, and especially in combination with a skin stimulation gave a large reinforcement. Even galvanization of the spine increased the kick.

This question was followed up by Lombard (1887), who showed that even spontaneous skin sensations of no marked intensity may act as reinforcements. He also showed that a large variety of influences which may be vaguely classified as emotional (noises such as to arouse attention or interest, music, "exciting dreams") exaggerate the jerk. Less clear is the pronounced effect of mental activity (multiplication, recalling a stirring poem) since this may be accompanied by unintentioned muscular movements. Others also have observed these effects of mental states (sorrow, joy, mental excitement). Ferguson notes an exaggeration in two cases of fright, and Russell, more recently, has expressed the belief that a "purely mental process" suffices to increase the knee-jerk. Whether the will alone can influence this movement is at the best uncertain. Some of my own experiments with other tendon reflexes distinctly indicate that it may, but Erb pointed out at the very beginning that it is very difficult voluntarily to inhibit the jerk. On the other hand there is no reason to suppose that volition is in play in the long series of Lombard and of Bowditch; the experiments were too carefully varied to permit any such objection. Some investigations have been made with demented persons in the hope of eliminating at least a portion of the incessant variation of jerk. The results were in no way more satisfactory and the practical difficulties were found to be great. While the feeble knee-jerk of health may be increased by hand clenching, an enfeeblement due to disease may not be thus reinforced (Ferguson).

In the experiments with reinforcements the investigators had laid stress upon a certain coincidence of the tendon tap and the reinforcing act. The time relation of these events was examined with much care by Bowditch using an ingenious and refined method. The results obtained are most surprising and have never received quite the attention they deserve. It was found not only that the voluntary movement must be made within a definite time interval in order that the kick may be distinctly increased, but also that for certain intervals the effect may be a diminution of the movement. Thus we may have either a reinforcement or an inhibition which it is convenient to call a negative reinforcement, just as the physicist calls suction negative pressure.

More precisely the result was this: when the *signal* for a muscular movement (hand squeeze) coincides with the blow upon the tendon the knee-jerk is larger, having one hundred and fifty to one hundred and seventy per cent. of the average "normal" (*i.e.*, unreinforced) kick of the day or series. When the signal precedes the tendon tap the effect diminishes as the interval increases, becoming a negative reinforcement when the interval has passed a certain value, varying from 0.22″ to 0.6″ in these experiments. The average decrease in the size of the jerk for many series was sixty to ninety per cent., but in single experiments there was a reduction to zero, a complete inhibition. The greatest diminution was for intervals of 0.6″ to 0.9″ beyond which there was a gradual return to the normal value, complete after 1.7″ to 2.5″. Altogether six persons gave very similar results, the details being worked out in very extended series of experiments upon two of them. Two other persons gave only positive reinforcements.

Bowditch also made a careful investigation of the time relations of sensory reinforcements. A sudden auditory stimulus (torpedo) gave almost wholly positive reinforcement in three subjects, the maximum effect being for an interval of 0.2″ to 0.3″. Visual stimulation by a sudden but not painful flash of light (necessarily involving an involuntary wink) caused almost wholly positive reinforcement in two subjects, while in the third there was a negative reinforcement for intervals greater than 0.4″. Very similar results for these three subjects were produced by a brief blast of air directed upon the conjunctiva, which would also cause an involuntary wink. That the wink movement was not the only influence involved was made clear by experiments in which the blast of air was directed to the mucous membrane of the nose, in only one person to be sure, but causing positive and negative reinforcements very similar to those produced by visual or conjunctival stimulation. In two persons a gentle skin stimulation was produced by directing a blast of air against the back of the neck; in one the result was almost entirely a positive reinforcement, in the other there was a positive and a negative phase, the latter being more conspicuous. When the blast of air was directed to the skin of the knee the result, only one person being experimented upon, was nearly altogether a negative reinforcement varying in amount with the interval. In all these experiments the attention was fixed as uni-

formly as possible by requiring the subject to announce whether the kick had been "normal" or "reinforced." The time relation of painful sensations was not studied.

Evidently the range of variation in the phenomenon is exceedingly great and depends upon many circumstances which are not easily controlled. This fact should be borne in mind in interpreting the diagnostic significance of the knee-jerk. There is not only much variation in the size of the kick but there are pronounced changes in its character (easy and hard, slow and quick or peculiarly jerky). These changes have not been sufficiently studied.

It was natural to inquire whether the sensory reinforcements depend upon cerebral or at least higher centres. Reichert (1890) experimented to this end on dogs whose cords were cut in the lower cervical or upper dorsal region. His results were entirely negative. But Sternberg (1891) obtained positive results in such dogs, and this would seem to be in accord with the earlier experiments of Goltz and Freusberg on the isolated lumbar cord.

Hughlings Jackson (1892) has suggested that in many cases where the Kj. is lost (some forms of apoplexy, some epileptic attacks, etc.), a supervenosity of the blood is the cause. This has been worked out more fully by Russell (1893). In the earlier stages of asphyxia there is a very marked increase in the vigor and force of the response, later a diminution and loss with a gradual return upon resuscitation. Russell considers lack of oxygen to be the chief cause of these changes, a definite balance of oxygen being necessary while the action of carbon dioxide is nowhere in play. The action of nitrogen inhalation is similar but the effects come on more slowly. Ferguson (1892) has published several cases which seem to offer a confirmation of Jackson's view. Lombard's earlier experiments with asphyxia are probably complicated by other influences.

As to the general action of drugs on the knee-jerk our knowledge is not very extended or exact, and there is no little disagreement in the reports. Some of the discrepancies are probably due to the varying susceptibility of the animals used.

The jerk is increased by strychnine and absinthe, diminished by morphine, but the authors are not in accord. Bromism augments the reply (Seguin, Ferguson) "by removal of cerebral influences." The phenomenon is abolished in the deep coma of poisoning by cyanide of potassium or illuminating gas, and in the sleep of chloral (but not in the cat even when the insensibility is profound). Alcohol is said to cause at first, in moderate intoxication, an augmentation but later a diminution of the kick; noteworthy is the return of the lost Kj. of ataxia during intoxication, analogous to the return caused by hemiplegia, according to Hughlings Jackson. Cocaine at first increases but later abolishes the phenomenon. Nitrite of amyl is without effect. Curare causes the kick to disappear. Concerning the action of nitrous oxide there is a disagreement: according to Horsley (1883) it causes no abolition even in deep narcosis, while the experiments of Russell (1893) in animals show an abolition with a preliminary exaggeration which also occurs during recovery, as in asphyxia. Ether is said to cause a preliminary exaggeration with loss of the jerk during deep narcosis (but not in the cat) and another period of augmentation as the effect passes off. There are apparently pretty marked differences in the groups of animals. The effect of chloroform is similar except that the Kj. is lost sooner and the return is slower; it also abolishes the Kj. in the cat.

For the production of the knee-jerk an intact "reflex arc" is essential: tendon, quadriceps muscle, crural nerve, and a certain part of the cord. The tendon is believed to act merely as the transmitter of a mechanical stimulus (either a pull or vibrations) since no other form of stimulation is effective, and the tendon may be extensively crushed or replaced by a cord without impairing the response. The stimulation takes place either at the border of tendon and muscle or among the muscle fibres. In the former region are nerve terminations (Golgi's "*organi nervosi terminali musculo-tendinei*," or "tendon spindles") which are unquestionably sensory. In the muscle are the so-called "spindles" whose character has been much discussed. The studies of Sherrington show them to be connected with afferent nerve fibres so that they may have a sensory function. There are also other nerve endings and terminal structures attached to nerves among the muscle fibres capable of acting in a similar fashion. The local action of cocaine in abolishing the jerk favors the view that such sensory nerve terminations are concerned in the act.

The muscle involved is commonly said to be the *m. quadriceps femoris*. On this point the most extended research is that of Sherrington (1892), who, working on the monkey (Macacus rhesus) and other laboratory animals, showed that not all the divisions of this muscle are essential. The portions chiefly concerned are the *m. vastus internus* and the *m. crureus* (*m. vastus medialis* and *m. femoralis* of the new nomenclature).

The nervous pathway, as was seen in the earliest investigations, lies in the crural nerve, but Sherrington found that only the branches pertaining to the muscles named are absolutely essential. All other branches, as well as all other nerves going to the knee region, may be cut and the jerk remains brisk.

The portion of the cord directly involved in the knee-jerk has been studied with great diligence. Tschirjew (1878) showed that the entrance of the sixth lumbar nerve marks the region whose destruction stops the Kj. in the rabbit. This was confirmed by Prévost (1881) and by Sherrington (1892–93), who also found that section of the fifth posterior root is sometimes effective. To Sherrington we owe most extended and interesting studies of this question. In some cats the root on which the Kj. chiefly depends is the sixth lumbar, in others it is the fifth. In the monkey (Macacus rhesus) the spinal centre was found to be in the fifth and fourth lumbar segments (fourth and third of man). The afferent pathway lies in the posterior root of the fifth lumbar nerve (fourth of man) but a small portion of it may lie in the fourth root; the efferent roots essential to the jerk are the fourth and fifth lumbar. This result is also concordant with an observation of Ferguson (1894), who saw a case in which a stab in the back had healed with loss of the Kj. and marked atrophy of the vastus internus and crureus as the only results of note, while the autopsy (fifteen years afterward) showed a destruction of the fourth lumbar nerve, the roots above and below being apparently perfectly healthy.

Sherrington found the posterior root exceedingly sensitive to all sorts of influences. It may be affected (and the Kj. abolished) not only by partial section (demarcation currents), cooling, carbonic-acid gas, cocaine, but even by slight mechanical disturbances (as lifting by a thread) which do not obviously impair the tactile sense. This suggests that the fibres involved may have some peculiarities of structure which may again include peculiarities as to irritability and conductivity. The very earliest students of this question had observed this sensitiveness of the crural nerve.

Important also is the observation that section of the ventral roots below these essential roots makes the Kj. more brisk and section of the dorsal roots has a similar result. This effect persists in the monkey for several months and seems to be due to the destruction of the tone of the hamstring muscles. It resembles the result of high section of the sciatic which also augments the kick, as Tschirjew first showed. The phenomenon in question is something more than a mere mechanical freeing of the knee-joint, it is rather the interruption of a stream of centripetal influences passing from the hamstring muscles to the cord and there exerting a depressing or restraining influence on the jerk. An influence of similar character may be produced by moderate electrical stimulation of the central end of the hamstring nerves, by stretching or kneading the muscles when freed at the knee, or even by electrical stimulation of their motor roots so long as the sensory roots are intact. Such results in relation to the Kj. are said not to be obtained

with other muscles and are due to a reflex tonic action influence of one set of antagonistic muscles upon the other set, despite the fact that they belong to different segments and the reflex is obtained across several intervening segments. This ascending reflex inhibition of the kick is not affected by a median longitudinal section of the cord from the second lumbar segment to the end, nor does such a section impair the Kj. on either side. The observation that pressure on the sciatic inhibits the Kj. (Mitchell) finds an explanation in this hypothesis.

While all agree that the integrity of this reflex arc is fundamental, there is diversity of opinion as to the way in which it participates in the knee-jerk. Some hold with Erb that the entire event is a reflex not essentially different from other reflexes. Others, following Westphal, consider that the jerk is in some fashion a direct response to the pull of the tendon, the arc being necessary to keep the muscle in proper condition for the response by maintaining a tonus. A third view, associated with the name of Gowers, that the stretch of the muscle makes it more ready to respond to local stimulation is a modification of the direct-answer theory and has met with little acceptance. Gotch apparently considers that the reply to the tendon tap may be a direct mechanical excitation or, at times or in certain vertebrates, a true reflex discharge; the result varying with conditions not altogether discernible or under control. A similar view has been advocated by others who, however, have been inclined to go further and think that both forms of reply may possibly occur together. This would explain the great variety in the time of the response.

For those who deny the reflex character of the knee-jerk a strong argument is found in the quickness of the process. Others, realizing that our knowledge of reflex time is at the best very deficient, do not find that argument convincing. It is desirable to remember that the results of the different observers are very far apart, and a suspicion is awakened that the observations may not all belong to the same process. The knee-jerk may be a reflex *sui generis* quite unlike other reflexes as to time because the conditions are peculiar and possibly because nerve fibres of a different conductivity are involved. An extraordinary slowness of responses has sometimes been observed, but its significance is unknown.

The important figures for the time of the knee-jerk in man are these: Tschirjew (1878) 0.0595″; Gowers (1879) 0.10″ (0.09″–0.15″); Brissaud (1880) 0.050″; Waller (1880) 0.035″; de Watteville (1882) 0.03″; James (1882) 0.025″; Eulenburg (1882) 0.0242″; Rosenheim (1884) 0.043″; Lombard (1887) 0.073 (0.051″–0.093″); Jendrássik (1894) 0.032″; Glynn (1896) 0.025″ (noted by Gotch); Stewart (1897) 0.069″. For the crossed reflex the last two observers report the time to be 0.110″ and 0.126″ respectively. It will be observed that some of the higher figures were obtained by experimenters of much skill and experience.

For animals we have also time determinations of this phenomenon. For dogs Applegarth (1893) found the Kj. required 0.014″ to 0.020″, the time being somewhat smaller when the cord is cut than when it is intact. For the rabbit Rosenheim (1884) found 0.033″; Waller (1890) 0.008″ (a result "corrected" from 0.012″), and Gotch (1896) has a similarly astonishing result for a "slip of vastus internus," the time from tendon tap to contraction being 0.005″ which he says should be reduced to about 0.003″!

It is commonly maintained that the time of the Kj. is nearly as quick as that of direct muscle stimulation, but the investigators of this phenomenon are also not in accord. Tschirjew's time for two men is 0.027″–0.026″; Waller's time is 0.020″ (for mechanical stimulation, 0.030″); Lombard for three men has a mean of 0.064″; Jendrássik about 0.0085″. For the rabbit Waller (1890) notes 0.0076 for electrical stimulation (0.0078 for mechanical), Gotch 0.005 as a minimum.

Our knowledge of "reflex" times is also not very satisfactory. Waller gives 0.10″–0.15″ for a reflex from a skin stimulation to a movement of the thigh. He holds this to be a true reflex but thinks that the cerebrum may be involved. Lombard's reflex time for an electrical stimulation of the skin of the knee is 0.253. Applegarth found the reflex time for a skin stimulation of the toes in a dog whose cord had been divided for nine months equal 0.0714″ In the rabbit (in a sort of "hypnotic" state) Waller determined the reflex time for a skin stimulation of the leg to be 0.0333″; for a reflex due to a blow on the board on which the animal lay 0.036″. Broca and Richet found the time of a similar reflex in a rabbit made quiet but extremely sensitive by chloralose to be 0.042″–0.050″ for temperatures of 40°–35° C. The cremaster reflex of the rabbit in reply to an electrical stimulation of the fascia is given as 0.050″–0.060″.

Stress is commonly laid on Exner's determination of the eyelid reflex in 1874 as the best determination of a reflex time. Exner found a mean of 0.0578″ or 0.0662″, according to the strength of the stimulus, and calculates the portion belonging to the process going on in the gray matter to be 0.0471″ and 0.0555″ respectively. Waller says he has verified Exner's results. It is therefore *assumed* that the participation of the gray matter of the cord in the production of the Kj. will require at least this time. If this be true even the figures of Lombard or Stewart are not large enough for a "reflex" after deductions for the time of transmission and for the latent period of the muscle. On the other hand, it seems to be commonly forgotten that Exner's reflex was a crossed reflex from one eye to the other. Then too this reflex time has been much reduced by the newer measurements of Mayhew (1897) using only one eye. The mean time for winking in sixteen persons was 0.042″ (0.0351″–0.0491″). Making the same reduction as Exner made for his results, we have for the time of the central process 0.0313″; whether the time for analogous gray matter activities in the lumbar cord is the same, no man knows.

The tonus theory of the knee-jerk also presents difficulties. For a long time its advocates were rather half-hearted in their support, but of late they have grown more courageous and insistent. It seems to have become a dogma for many that because there is much vagueness about muscle tonus it must needs be denied altogether. On the other hand, an admission of its existence does not involve the admission that the knee-jerk is merely a variation of tonus. Such an explanation of the kick is most unconvincing. So far as the study of the form of the contraction of the quadriceps goes it apparently does not differ from other forms of twitch, but this question calls for further investigation. While it is perfectly true that a certain tension is most helpful, the knee-jerk is often demonstrable when the muscle is perfectly relaxed (Erb, Mitchell). Muskens has urged that the knee-jerk and the true reflexes do not vary together in some lesions of the cord as he thinks they should. His also finds a certain parallelism between the tonus and the tendon reflexes. His cases (as well as those of Fraenkel and Collins, 1900) are not very convincing, and there are many other observations which show that the two processes may well be held to be distinct. Certainly, as Neumann (1896) has remarked, the tonus theory seems to be unnecessary and only complicates our understanding of the tendon phenomenon. The most recent study of tonus and its relation to the knee-jerk will be found in two articles by Langelaan (1901, 1902), but he seems to neglect the fact that the jerk continues when the antagonistic muscles are excluded from all participation in the process. If there be a tonus and it be a reflex, as there is a growing disposition to admit, its time relations present problems not less perplexing than those which belong to the view that the knee-jerk is itself a reflex.

Other advocates of a tonus doctrine seem to take a position rather different from that of their predecessors. Stress is beginning to be laid upon a nervous tonus, which is apparently not quite the same thing as the older muscle tonus, for it seems to mean merely those impulses which flow from higher centres and regulate or tone the condition of the motor cells in the anterior horns. This stream is apparently not necessarily due to incoming peripheral stimulations, although such factors may affect it. This view has been developed to explain the diminution

or loss of the Kj. in man when the cord is injured at a high level. A dozen years ago Bastian called attention to the disappearance of the Kj. in such transverse lesions, not altogether unknown before, and since that time many such cases have been reported which seemed to justify the position that the removal of cranial or cerebro-spinal influences was the true explanation of the results. Out of these cases have grown extended discussions, some of which are almost painfully ingenious. The most interesting and important are perhaps those of Van Gehuchten (1897, with a modification in 1901), Koll (1898), and Brasch (1900). Nearly all the cases reported are defective because there is not a complete microscopic examination of the lumbar cord and the structures forming the reflex arc of the knee-jerk. Under these circumstances a single case of complete transverse destruction of the cord without loss of Kj. outweighs any number of uncertain cases and their incidental theories. Such seems to be the case reported by Kausch (1901) in which the cord was accidentally severed in an operation rendered necessary by tuberculous processes going on in the spinal column. At first there was a total disappearance of the reflexes and of muscle tonus. The tonus returned in about forty-eight hours, and is said to have persisted in an exaggerated form until death five months and a half later. The reflexes came back some twenty hours after the operation (*i.e.*, many hours *before* the tonus), both skin and tendon reflexes recurring at the same time. Most of the reflexes persisted and were exaggerated until death, but the Kj. as well as the Achilles tendon reflex grew feeble toward the end and finally disappeared before death, as also happens when the cord is intact.

This brings the human cord again into line with the cord of other mammals, and confirms the opinion that it is easier to believe that the functional activity of the cord is substantially the same in the higher mammals than to assume that the human cord is radically different. It has been shown again and again in the past twenty-five years that the knee-jerk returns when the cord is cut in the middorsal region in most laboratory mammals and persists for a long time. Applegarth experimented with the jerk of a dog nine months after such a section. Sherrington's monkeys regained their knee-jerks after section of the cord at the proper level and retained them for months. The evidence for other mammals is similar, but the observations have not been continued so long. The lumbar cord is the seat of all those spinal processes that are essential to the knee-jerk. By this is not meant that the jerk is necessarily the same after cord section as before, in fact it is generally larger and it may differ in form; there seem to be no exact measurements. Unquestionably there are influences flowing constantly from the various parts of the encephalon which profoundly affect the activities of the cord and may exalt or depress the knee-jerk, but that this permanently disappears when these influences are excluded it is not heresy to doubt. The temporary disappearance may be due to "shock," and this may mean nothing more than a more or less profound alteration of the circulation of the lower cord with incidental nutritive changes from which recovery is quite possible. The stimulation of inhibitory nerve fibres is also a plausible explanation, but this effect ought to pass away speedily in the absence of any irritating or inflammatory reactions. It may be the expression of a decentralization of spinal centres which have been strongly dominated by higher centres, as seems to be more markedly true of the higher vertebrates, and which require time to readjust themselves to a new and more independent condition. On the other hand, we may suppose that peripheral influences are equally constantly flowing into the higher centres to arouse them to participate more actively in the regulation of body movements.

For the participation of the cerebral lobes there is considerable evidence, and some have held the reinforcement of voluntary movements to be due to a diversion of "attention." Weinberg's results (1894) from stimulation or extirpation of motor areas, while in general favorable to the view that the cortex has influence on the Kj., are not so convincing as one could wish. The removal of a cerebral lobe increases the opposite knee-jerk (Russell, 1893). The effect of cerebral hemorrhages and of brain compression seems to show that the cerebrum does inhibit. Uncertain is the interpretation of the action of galvanization through the region of the temples (Mitchell and Lewis). Pándi (1895) seems to suppose the cortex to inhibit through the antagonistic muscles, while the commoner view is that some system of inhibitory fibres runs down the cord and directly affects the motor cells.

Van Gehuchten, although he makes the tendon reflex depend upon a rubro-spinal path (red nucleus, fascicle of von Monakow), and therefore mesencephalic in origin, considers that fibres of the cortico-spinal path have an inhibitory influence.

As to the action of the cerebellum, we have very definite experiments by Russell (1893) showing that the extirpation of a lateral lobe augments the Kj. of its own side and diminishes that of the other side, and a distinct but irregular increase is produced by extirpation of the posterior part of the vermis. The effect persists too well to be irritative; it is paralytic. Whether this is an influence through the cerebrum is unclear. Bechterew's views concerning the paths from the cerebellum to the cortex cerebri seem opposed to this view. The theory of Gowers concerning the cerebellum as a regulating centre for such centripetal impulses of the muscle sense as stand in some special relation to motor processes particularly concerned in equilibrium and in coördination of movements would seem also to become untenable.

Van Gehuchten in his earlier article includes the cerebellum along with the mesencephalon and the rhombencephalon in the structures which constantly send exciting influences to the motor cells of the anterior horn by way of cerebello-spinal fibres and the longitudinal posterior fascicle. In his later article he seems inclined to limit this stimulation to the rubro-spinal path. For him the normal muscle tonus is only the external manifestation of the state of more or less permanent excitation in which these motor cells find themselves. As a condition of tonus exists in the isolated lumbar cord and may be constantly affected by the impulses of the muscles there innervated, as Sherrington's experiments show, this complex relation can only be of secondary importance.

A similar inference seems to be permitted concerning the reflex centre in the "*regio bulbocervicalis*" just below the tip of the calamus scriptorius (Rosenthal and Mendelsohn, 1897), which has been a source of comfort to many neurologists in recent years, a comfort which must be somewhat unreal until the doctrine is much more firmly established.

As to the nature of the reinforcement, both positive and negative, we are very much in the dark. We can hardly attribute them all to mere change of tonus, nor do there seem to be any experiments to show that tonus is thus changed. The theory that there is some sort of an "overflow" for every motor or sensory stimulus, or even emotion, and also the theory that every such stimulus in some way removes a check, does not fully account for the negative phase of reinforcement. The suggestion that a fatigue phase is in play is hardly plausible in view of the slightness of sensory stimulus found to be effective. The theory (Brunton) that nerve impulses may coincide or interfere like light waves, producing an augmentation or diminution according to the phase, is ingenious but difficult of interpretation.

While many of the reflexes are evidently protective, this is not the obvious purpose of the tendon reflexes. It seems reasonable to think, with Koll, that the knee-jerk is an extreme expression of a reflex stimulation constantly produced in a slight form by the tendons, periosteum, and joints and having an important regulatory influence on the entire mechanism of movement. Such tendon reflexes are perhaps of prime importance in certain particular kinds of movements and may have but a small share in the general coördination of body movements. There need then be no pronounced parallelism between the loss of a tendon reflex and ataxy, since the

tendon reflex is only a part of the coördination. A connection between the lumbar reflex arc concerned in the knee-jerk and the cerebellum by means of coördination pathways may be assumed, but there is no reason for postulating a direct pathway to the cerebellum, nor do the pathological observations demonstrate such.

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KNEE-JOINT.—Whether considered from the anatomical or the surgical point of view, this is the most important joint in the body. It is at the same time the most complicated and the most difficult to understand. Its surfaces are necessarily large to support the weight of the body, and as there is not that close adaptation which is shown at the elbow and hip, its great strength depends upon the surrounding ligaments, fascia, and muscles, which are so effective that dislocation is rare. Its vast extent of synovial membrane predisposes it to inflammation, and its exposed situation renders it liable to injury. Its structure is more readily understood when it is regarded as an assemblage of three joints originally distinct, viz., a patello-femoral and two femoro-tibial. That this is a correct assumption is rendered probable by slight furrows upon the articular surface of the femur (not clearly shown in Fig. 3082) which separate a patellar surface from the two condyles, and the arrangement of the ligaments also amply confirms it; there being besides the capsular, investing the whole joint, certain internal ligaments which are vestiges of the original separate condition. From the middle of the joint, between the two condyles, pass downward and outward two folds of synovial membrane laid upon a thin connective tissue. These are the ligamenta alaria, and they indicate the line of separation into three cavities. Again, there are certain bands accessory to the capsule. Externally these are known as the lateral ligaments (Figs. 3082 and 3083), internally as the crucial ligaments (Figs. 3082 and 3083).

The former pass from the tuberosities of the femur to the shaft of the tibia and the head of the fibula on either side; the latter are short bands arising from the femur,

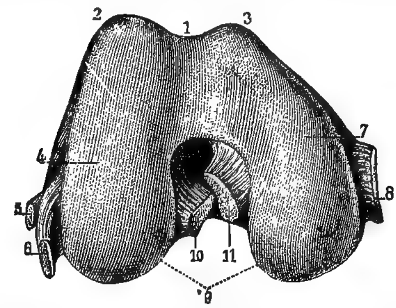

FIG. 3082.—Upper Articular Surface of the Knee-joint. (Sappey.) 1, The patellar groove; 2, outer edge; 3, inner edge, less elevated than the other; 4, outer condyle; 5, external lateral ligament, cut; 6, section of the popliteus muscle obliquely directed downward and inward, and covered by the external lateral ligament; 7, inner condyle; 8, internal lateral ligament, cut; 9, intercondylar notch; 10, section of the anterior crucial ligament inserted upon the posterior part of the inner surface of the external condyle; 11, section of the posterior crucial ligament inserted upon the anterior part of the outer surface of the internal condyle.

on either side of the condylar notch, to insertions in front and behind the spine of the tibia. These accessory bands limit and control the motion of the joint, as do similar structures elsewhere. On complete extension, the whole system is locked by the tension of the lateral and the anterior crucial ligaments, so that no muscular force is required to hold the knee firm in the erect position, the weight of the body falling in front of the joint and fixing it. When the joint is thus fixed and muscular action suspended, a slight blow from behind will throw the whole apparatus out of equilibrium, and occasion a sudden flexion of the limb.

This tripartite division of the joint corresponds to its condition in many lower animals, in which the three synovial cavities are either totally distinct, or communicate by small openings.

The irregular form of the joint surfaces is due mainly to the action of the muscles. While at the elbow the

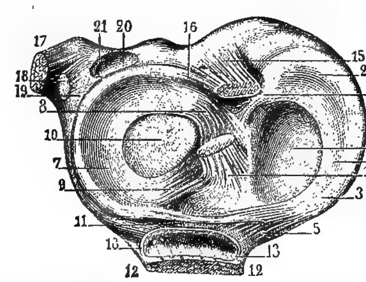

FIG. 3083.—Lower Articular Surface of the Knee-joint. (Sappey.) 1, 2, 3, Internal semilunar fibro-cartilage; 4, its attachment to the depression behind the spine of the tibia; 5, its anterior attachment; 6, that part of the internal glenoid cavity not covered by fibro-cartilage; 7, external semilunar fibro-cartilage; 8, 9, its attachments; 10, part of the external glenoid cavity not covered by fibro-cartilage; 11, transverse ligament; 12, ligamentum patellæ, cut; 13, bursa subpatellaris; 14, tibial insertion of the anterior crucial ligament; 15, of the posterior crucial ligament; 16, band of fibres which unites the external semilunar fibro-cartilage to the posterior crucial ligament; 17, tendon of the biceps, cut; 18, external lateral ligament, cut; 19, groove for the tendon of the popliteus; 20, bursa poplitea; 21, orifice occasionally found by which the cavity of the upper tibio-fibular articulation communicates with that of the knee-joint.

flexors, but two in number, come down and are inserted near the plane of movement, at the knee there is a series of flexors stretching over the joint from above, and inserted partly on the outside and partly on the inside of

the leg; so that, when acting separately, they tend to twist the tibia upon its longitudinal axis. It will be observed also that while a single muscle, the biceps, is inserted on the outer side, there are four muscles (sartorius, gracilis, semitendinosus, and semimembranosus) Figs. 3084 and 3085), inserted upon the inner side, the insertion running from the tuberosity of the tibia some distance down the shaft. The consequence of this would naturally be to give more range of motion to the inner condyle, and an examination of the joint surfaces shows that they are correspondingly shaped to that end.

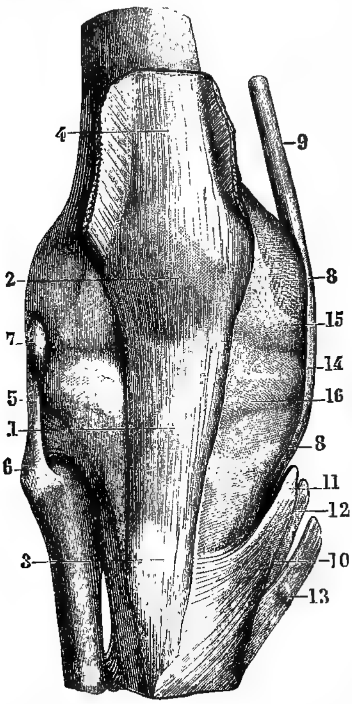

FIG. 3084.—Anterior Surface of the Knee-joint. (Sappey.) 1, Ligamentum patellæ; 2, its expansion over the patella; 3, its insertion upon the tibia; 4, tendon of the quadriceps extensor femoris; 5, external lateral ligament; 6, its insertion upon the head of the fibula; 7, tendon of the popliteus; 8, internal lateral ligament; 9, tendon of the adductor magnus; 10, fascial expansion of the internal hamstring tendons (*patte d'oie*); 11, tendon of the sartorius; 12, tendon of the gracilis; 13, tendon of the semitendinosus; 14, internal semilunar fibro-cartilage; 15, the upper synovial cavity of the joint; 16, lower synovial cavity, separated from the preceding by the fibro-cartilage.

The inner condyle (Fig. 3082) is bent not only from before backward, but also from side to side like the half of a horseshoe, and roughly corresponds to a cone whose apex is at the insertion of the posterior crucial ligament. The outer condyle is bent only in one direction, but its surface corresponds in a similar way to a cone whose apex is somewhere within the anterior crucial ligament. There is thus seen to be a provision for a double motion of the inner condyle, a back-and-forth hinge action, and a rotation around the outer, while only the hinge motion has shaped the outer condyle. The peculiar action of these surfaces does not admit of their being fitted into a socket, regular and invariable in form. There are accordingly developed around the edge of the corresponding portions of the tibial surface two fibro-cartilages, called the external and internal semilunar (Fig. 3083). These are loosely attached, running at either end into fibrous tissue which is inserted in front and behind the tibial spine, and along their circumference being comparatively loose, merely united with the capsule. Synovial membrane covers both their upper and their lower surfaces, so that they are freely movable. They correspond in a general way to the impression made by the heads of the condyles, but their elasticity is such that, whenever the condyles move and twist, they follow their movements.

The general capsule of the joint (Figs. 3084 and 3085) is very extensive, reaching above and below beyond the articular surfaces of the femur and tibia, and blending with the tendons of the surrounding muscles and their fascial insertions. It is thinnest just above the patella on either side of the tendon of the quadriceps, and here it is that effusion is most likely to show. The extent of the joint cavity upward is here so great that the serious mistake has been made of opening a fluctuating tumor here, thereby entering the cavity and endangering the limb. The tendon of the quadriceps passes down in front to the patella (properly considered as a sesamoid bone, developed in its substance), and is continued on, beyond that bone, to the tuberosity of the tibia as the ligamentum patellæ (see Fig. 3084). The whole system answers the purpose of an anterior ligament to the joint.

Of the lateral ligaments (Figs. 3086 and 3087), the external is the shorter, and of the shape of a rounded cord, which may be felt on the outer side of the leg just above the head of the fibula; the inner is longer and flatter, giving more latitude of motion. The points of their origin from the femoral condyles are in the axis of the cones described by the surfaces. They are not, like the lateral ligaments of the elbow-joint, tense in every position, but allow the twisting motion of the tibia above mentioned. A second or short external lateral ligament is also described, passing from the condyle of the femur in connection with the head of the gastrocnemius, and inserted into the styloid process of the fibula. It is not constant. Behind, the capsule is broad and sheet-like (Fig. 3085), receiving fascial expansions from the tendons of the semimembranosus and popliteus. The band from the semimembranosus is sometimes described as the popliteal ligament, and the whole sheet as the posterior ligament of Winslow. It is everywhere of sufficient thickness to resist the irruption of abscesses from the popliteal space into the joint, but pus has been known to burrow from the synovial cavity outward below the popliteal ligament. This posterior sheet offers the principal obstacle in contracted knee, when associated with fibrous ankylosis. This is probably owing to the fact that it contains but little elastic tissue, and an increase of the white fibrous elements produces, as elsewhere in the body, a certain amount of contraction.

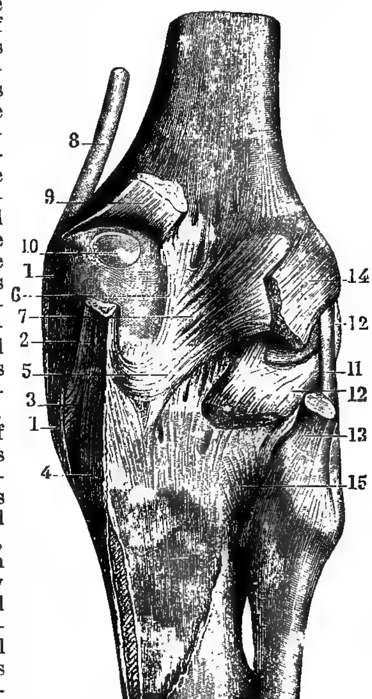

FIG. 3085.—Posterior Surface of the Knee-joint. (Sappey.) 1, 1, Internal lateral ligament; 2, tendon of the semimembranosus; 3, its anterior or reflected portion; 4, its middle portion attached to the posterior part of the internal tuberosity of the tibia. From this middle portion two expansions extend; one reaches the lower part of the internal tuberosity, the other is continuous with the aponeurosis of the popliteus; 5, posterior portion of the tendon of the semimembranosus. It forms a posterior ligament directed upward and outward, to be inserted upon the external condyle; 6, 7, fibres of this tendon directed vertically upward; 8, tendon of the adductor magnus; 9, tendon of the internal head of the gastrocnemius; 10, orifice often found in the fibrous capsule over the internal condyle; 11, external lateral ligament; 12, tendon of the popliteus; 13, tendon of the biceps; 14, tendon of the external head of the gastrocnemius; 15, the posterior superior tibio-fibular ligament.

The synovial membrane is very extensive, passing beyond the articular surfaces above, and traceable therefrom downward on either side to the semilunar cartilages forming the ligamenta alaria before mentioned. There is here, interposed between the membrane and the ligamentum patellæ, a large pad of fat, from

which there passes backward to the intercondylar notch a process of connective tissue, the ligamentum mucosum (Fig. 3088). After covering the upper side of the semilunar cartilages the synovial membrane passes to their under surfaces, and from thence on to the upper surface of the tibia. There are several openings by which the synovial sac communicates with the neighboring bursæ. The principal one is above, where is a large orifice, nearly constant, opening into the bursa subcruralis (Figs. 3086 and 3087). Another, always found, communicates with the bursa under the tendon of the popliteus (Fig. 3083), and from this there is an occasional diverticulum connecting with the superior tibio-fibular articulation. A third communication is with the large bursa under the internal head of the gastrocnemius. Many other bursæ are found near the joint (see article on *Bursæ*, vol. II.), and some of them may occasionally connect, so that extreme care is always required in operations in this region, lest the opening of one of these sacs should involve the joint cavity.

The movements of the patella are not only gliding, but slightly rolling or coaptative. The bone is adapted to the shape of the hollow between the condyles by a ridge which divides it into two unequal, lateral portions. Each of these is again divided into facets, so that, taken from above downward, the contact of the bone with the femur is but slight, especially during flexion. It is this circumstance that causes the frequent fracture of the patella by muscular action. It forms a wedge-like body,

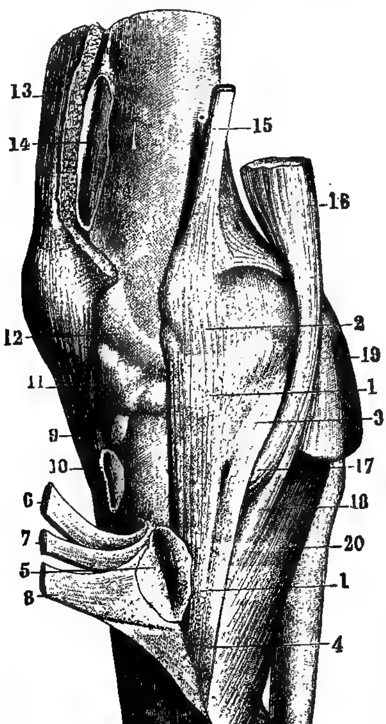

FIG. 3086.—View of the Knee-joint from the Inner Side. (Sappey.) 1, 1, Internal lateral ligament; 2, its insertion upon the tuberosity of the internal condyle; 3, its insertion upon the internal semilunar fibro-cartilage; 4, its insertion upon the upper end of the internal surface of the tibia; 5, bursa tibialis interna; 6, tendon of the sartorius; 7, tendon of the gracilis; 8, tendon of the semitendinosus; 9, ligamentum patellæ; 10, bursa subpatellaris; 11, adipose tissue near its upper part; 12, superior synovial cavity; 13, tendon of the quadriceps extensor; 14, bursa subcruralis; 15, tendon of the adductor longus; 16, 17, tendon of the semimembranosus; 18, its middle portion; 19, tendon of the internal head of the gastrocnemius; 20, the popliteus.

in contact with the articular surface only by a narrow edge, and the tendinous attachments are so arranged as to pull at right angles to each other directly over this edge. Any sudden jerk in this position has the same effect upon the bone as a sudden shock upon a stick over

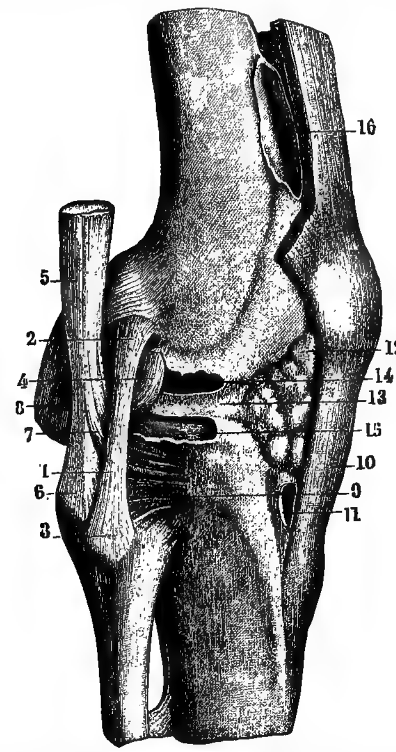

FIG. 3087.—View of the Knee-joint from the Outer Side. (Sappey.) 1, External lateral ligament; 2, its attachment to the external condyle; 3, its attachment to the external part of the head of the fibula; 4, tendon of the popliteus; 5, tendon of the biceps; 6, its attachment to the styloid process of the fibula; 7, the anterior or reflected part of this tendon, passing under the external lateral ligament, to be inserted upon the internal tuberosity of the tibia above the anterior ligament of the superior tibio-fibular articulation; 8, tendon of the external head of the gastrocnemius; 9, anterior ligaments of the superior tibio-fibular articulation; 10, ligamentum patellæ; 11, bursa subpatellaris; 12, collection of fat which fills the anterior part of the intercondylar notch. On each side it passes beyond the ligamentum patellæ; 13, external semilunar fibro-cartilage; 14, the superior synovial cavity, opened to show how it terminates upon the superior edge of the fibro-cartilage; 15, inferior synovial cavity, also opened to show its relation to the same fibro-cartilage; 16, bursa subcruralis.

the edge of a table. It is not strange, therefore, that it is more frequently broken by muscular action than any other bone in the body.

Atmospheric pressure is not without effect on the joint. In conditions of health it holds the patella firmly down and prevents its dislocation. In cases of opening the joint, or where there is effusion, the bone becomes much more movable laterally, and may be spontaneously dislocated.

The movement of the tibia upon the femur is such that, with flexion and extension, a slight degree of rotation always takes place. This is due to the peculiar shape of the condyles above mentioned, and to the pull of the muscles. The joint cannot, therefore, be said to be a perfect hinge, there being a considerable amount of lateral motion. This is most free in the semiflexed state, and may then amount to

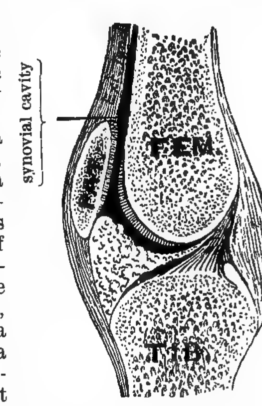

FIG. 3088.—Sagittal Section of the Knee-joint.

forty degrees. It is sometimes called pronation (which turns the toes in), and supination (turning them out), but is not produced by the same mechanism as the motions of the same name in the elbow-joint. The movements of flexion and extension do not exceed an arc of one hundred and sixty degrees.

The joint is copiously supplied with vessels from the femoral, popliteal, and anterior tibial arteries. The nerves are from both the sacral and the lumbar plexuses, the former through the sciatic, the latter through the anterior crural and obturator. It is interesting to note that interference with these nerves at any part of their course, or centrally, is followed by pain in the knee. The phenomenon known as "hysterical knee-joint," in which there is pain accompanied by no lesion in the joint proper, is usually thus explained. *Frank Baker.*

KNEE-JOINT, CONGENITAL DISLOCATIONS OF. See *Hip-joint, Congenital Dislocations of.*

KNOCK-KNEE.—(Synonyms: Genu Valgum, In-Knee.) In the erect posture the femora whose upper extremities are separated by the pelvis, incline slightly inward to the knee, forming angles at this point opening outward of about one-hundred and seventy-two degrees. The angle varies with the breadth of the pelvis, and in adult females, what may be called normal genu valgum, is often present. In compensation for the inclination of the femur the internal condyle is slightly longer than the external; thus the plane of the knee-joint is horizontal.

If the inward projection of the knees is increased to deformity the tibiæ are no longer perpendicular, and in the erect posture the feet are separated when the knees are in contact. In other words, the knees are in contact when the feet are in the proper attitude for walking, hence the term knock-knee.

In the slighter grades of knock-knee, due in great part to laxity of the ligaments, the deformity appears only in the upright posture, but in more marked cases it persists when the weight of the body is removed because it is caused by distortion of the bones.

FIG. 3089.—Typical Rachitic Knock-knees.

As has been stated, in the normal subject the inward inclination of the femur is compensated by the greater length of the internal condyle; and in the deformity of knock-knee the plane of the knee-joint is still preserved by what is apparently a further elongation of this part of the bone. In fact, it was thought at one time that the cause of knock-knee was hypertrophy of the internal condyle, but it is now generally accepted that the apparent lengthening is caused by deformity of the lower extremity of the shaft of the femur. This is bent with the convexity inward, so that the epiphyseal line has an increased obliquity. Thus it is apparent that the internal condyle is lowered by a deformity of the shaft of the femur and not by a change in the epiphysis itself.

FIG. 3090.—Knock-knee and Bow-leg.

In most instances there is a similar, although usually slighter, deformity of the upper extremity of the tibia, so that when the bone is placed in the perpendicular position its internal condylar surface is higher than the external. In rather unusual cases the deformity may be confined practically to the tibia.

In addition to these direct deformities there is a more or less constant change in the relation of the two bones, the femur is rotated inward and the tibia is rotated outward. In some instances there is a certain degree of over-extension at the knee; this is more often observed in the adolescent type, which is more directly dependent upon laxity of ligaments. In the ordinary form of rachitic knock-knee in childhood, however, the typical attitude is one of slight flexion of the knees, and in well-marked cases there may be limitation of the range of extension at the knee and at the hip also.

The deformity of knock-knee is most marked when the limb is fully extended, because the shortened tissues on the outer aspect of the joint become tense and because the outward rotation of the tibia is increased. As the leg is flexed the deformity lessens, and in complete flexion it disappears. This is explained by the fact that the posterior surface of the condyles is not affected by the deformity of the shaft, while the relaxation of the ligaments and the outward rotation of the femora permit the tibiæ to become parallel with one another. Thus slight flexion at the knees, which lessens the deformity, is the attitude which is often unconsciously assumed by patients.

The outward inclination of the leg increases the strain upon the foot and tends to induce the attitude of valgus, and rachitic knock-knee in the progressive stage is almost always accompanied by flat-foot. After recovery from the local or constitutional weakness the efforts of the patient to restrain the abnormal separation of the feet may induce the opposite attitude of inversion. In fact, extreme knock-knee is usually accompanied by a slight degree of fixed varus, and in the mildest type of knock-knee this compensatory effort of nature, shown by the so called pigeon-toed walk, may be the most noticeable symptom of the deformity.

As a rule, genu valgum is bilateral, but not infrequently it is unilateral, and again unilateral knock-knee may be accompanied by outward bowing of its fellow. In the slighter degrees of rachitic deformity outward bowing of the tibia may accompany inward inclination at the knee. Thus, in-knee and bow-leg may be present in the same limb. In the marked distortions of the lower extremity that are the result of rachitis the bones may be bent and twisted in various directions. For example, the femora may be bent forward and outward, above and inward, and backward below; the tibiæ may be bent inward above and outward and forward below. This is sometimes called "cork-screw" distortion, of which the outward expression is knock-knee.

FIG. 3091.—Adolescent Knock-knee.

In the more extreme deformities caused by rachitis the shape as well as the contour of the bones is changed. For example, the internal border of the tibia may become very prominent at its upper extremity and project beneath the skin like an exostosis. A change in the contour of the fibula accompanies and corresponds to that of the tibia, but it is, as a rule, less marked.

PATHOLOGY.—In rachitic knock-knee, the changes in the bones and in the epiphyseal cartilages are characteristic of that disease. In the milder degrees of deformity, however, aside from the change in shape and the accompanying transformation of the internal structure of the bones, there is little that is noteworthy. The tissues on the internal aspect are relaxed, those on the outer side, the lateral ligaments, the capsule, and the biceps muscle, are contracted. Within the joint slight changes in the articulating surfaces of the bones and evidences of chronic irritation of the synovial membrane are sometimes seen.

SYMPTOMS.—The deformity and the effects of the deformity on the gait and attitude are the most important symptoms, as they are of other distortions of similar origin. The gait of the patient with well-marked genu valgum is peculiarly awkward and shambling. The knees "interfere" and must be assisted, as it were, in the effort to pass one another in walking. In the slighter cases the thigh is abducted and rotated outward at the moment of passing its fellow, the movement being then reversed, as it, in its turn, supports the weight; but in the more severe type this voluntary effort of the muscles of the leg is not sufficient, and the body is swayed from side to side, the legs being alternately swung outward and lifted past one another.

In unilateral knock-knee, the leg being shortened by the distortion, a limp replaces the swaying gait.

ETIOLOGY.—Knock-knee is a deformity characteristic of weakness. The distortion is an exaggeration of the attitude of rest, and it may be assumed that in many instances the more or less constant assumption of the passive attitude, induced probably by weakness of the supporting muscles, is the cause of the deformity, the changes in the contour and in the internal structure of the bones being simply adaptations to the habitual posture. In the great majority of the cases the direct cause of the distortion is rachitis, and it develops therefore when the erect posture is assumed. In such instances a common attitude of the weak child is slight flexion at the three joints of the lower extremity, the knees being in contact with one another. To the habitual assumption of a somewhat similar attitude is ascribed the frequency of knock-knee among adolescent and adult bakers. It is probable also that postures assumed by the weak child in sitting and creeping before it begins to walk may determine the character of the subsequent distortion when weight is thrown upon the limb. One of the explanations of combined bow-leg and knock-knee is that the child has been habitually held upon the mother's arm in a manner to induce the deformity by direct pressure. Typical knock-knee is a deformity of childhood, but under favoring circumstances it may develop in adolescence. It is probable, however, that in many of these cases a slight degree of deformity was present in childhood, which later developed to noticeable distortion. Genu valgum may be induced directly by traumatism or by disease, and it may be a secondary or compensatory effect of deformity at the hip- or ankle-joint. These causes are, however, relatively insignificant.

TREATMENT.—Treatment of the deformity may be characterized as expectant, mechanical, and operative. During the expectant treatment the cause of the deformity, in most instances rachitis, should receive proper medicinal and dietetic treatment. If possible the direct exciting causes of the deformity should be removed; that is to say, the improper attitudes or the predisposing occupations should be discontinued.

In the slighter degrees of deformity, more particularly in weak or rachitic children, the limbs should be vigorously massaged at morning and at night, and forcibly straightened. The latter procedure is conducted as follows: The patient is seated in a chair; the leg is fully extended in order to make the deformity as extreme as possible; one hand then clasps the knee, the palm lying against its inner aspect; the calf is grasped firmly, and the limb is gently straightened over the fulcrum formed by the palm of the hand. This manipulation should be continued with gradually increasing force, although not to the extent of causing pain, for ten minutes, at least twice a day, and oftener if possible. This type of knock-knee, which is in itself an indication of weakness, is usually accompanied by flat-foot; thus the soles of the shoes should be made thicker on the inner border, as is described in the treatment of weak foot. If possible the patient should be instructed to walk with the feet parallel with one another, and tip-toe or other exercises in which the limbs are fully extended should be encouraged. A careful record of the deformity should be kept during this tentative treatment, and if there is some

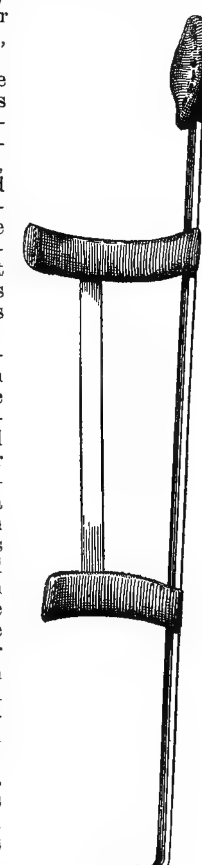

FIG. 3092.—The Thomas Knock-knee Brace.

improvement one is justified in delaying more radical measures.

There is, practically speaking, no spontaneous outgrowth of knock-knee deformity, such as is not infrequently observed in the opposite distortion of bow-leg.

Treatment by Braces.—The most efficient brace in the treatment of genu valgum is the simple straight steel bar or splint extending from the trochanter to the heel of the shoe, without joint at the knee. The greater efficacy of the rigid bar as compared with the jointed brace is explained by the fact that the rectifying force acts constantly when the joint is fixed, preventing the attitude of flexion so characteristic of the deformity.

The simplest and cheapest brace is that of Thomas (Fig. 3092), which consists of a light steel bar provided with a pad at its upper end for pressure against the tro-

FIG. 3093.—The Modified Thomas Brace with Pelvic Band, showing Over-correction of Deformity.

chanter, while the lower rounded extremity is turned inward at a right angle, to pass through the heel of the shoe. The knee is fixed by a posterior bar attached to a thigh and calf band, as illustrated in the figure. When the brace is applied the knee is drawn backward and outward, and is attached firmly to the brace by a roller bandage.

In the more extreme cases, in which the knees and thighs are habitually flexed, the addition of a pelvic band attached to the uprights by a free joint at the hips, adds to the comfort and efficiency of the apparatus, as the attitude of the feet can be regulated by twisting the uprights slightly, or the pelvic band may be divided, the two halves being attached to one another by straps and buckles (Fig. 3093). The uprights may be bent somewhat inward at first, and as the legs become straighter they are straightened and finally bent outward to allow for the over-correction of the deformity. Twice a day the braces should be removed to allow massage, manipulation, and voluntary exercises of the legs. In most cases the braces are not employed at night, although the rectification of the deformity may be hastened by their constant use. It is of course evident that mechanical treatment would be more effective if the child were not allowed to stand; as a rule, however, the brace must be employed as an ambulatory appliance.

If the deformity is unilateral so that a brace is required for one leg only, the other shoe should be raised by a cork sole about three-quarters of an inch in thickness to make walking easier. Children soon become accustomed to the braces and walk easily in spite of the absence of joints.

The duration of the brace treatment depends of course upon the degree of the deformity and the age of the child; from six months to a year is the ordinary period. Cure is assured by the gradual adaptation of the parts to the new static conditions, and by the transformation of the internal structure of the bone which accompanies the rectification of the deformity. When the braces are discarded attention should be paid to the attitudes, and exercises and massage should be continued with the aim of strengthening the muscles of the limb.

If the bones are very flexible, as in deformity due directly to rachitis in young children, it may be corrected rapidly by the repeated application of plaster bandages. This method is not often employed except in dispensary practice.

Operative Treatment.—Immediate correction of deformity, when it is at all marked, is as a rule indicated after the age of three or four years. For although it may be possible to correct the distortion by mechanical treatment in cases far beyond this limit of age, yet the time required and the incidental discomfort exclude it from consideration in all but very exceptional cases. Immediate correction of the deformity may be attained by osteotomy or by osteoclasis.

Osteotomy.—The so-called subcutaneous osteotomy is the operation of choice. The limb having been prepared in the usual manner is semiflexed and the inner surface of the knee is placed on a sand bag. With the fingers the femur is firmly grasped just above the condyles so that the size and position may be accurately determined, and a sharp osteotome about the size of a lead pencil is forced, with its cutting edge parallel with the axis of the leg, down to the bone, at a point about one and a half inches above the tuberosity of the external condyle. While it is held firmly in position against the bone, it is turned to the transverse direction and is then driven through the cortex. When it enters the medullary canal, as is made evident by the lessened resistance, it is partly withdrawn and moved slightly to one side and the other and driven through the cortical substance, until with gentle force the bone may be fractured. The osteotome is then withdrawn, the minute wound is covered with a pad of dry gauze, or, if the oozing be profuse, it may be closed with a catgut suture. The deformity is then overcorrected by bending the cortex on the inner side and opening a wedge-shaped gap in the bone, sufficient to make the patient somewhat bow-legged when the plaster bandage is applied. If the deformity is double, both limbs are operated upon, and, in order to assure better fixation, it is the rule to apply a spica bandage, double or single as the case may be, which includes the foot as well.

The plaster bandage is continued for from four to six weeks, and it is then usually supplemented by a brace. This may be worn with advantage for several months, because of the laxity of the ligaments of the knee-joint which is usually present in this type of marked deformity of rachitic origin. In less marked cases, particularly those in older subjects, the support is unnecessary. Massage and exercises during the stage of recovery should be employed if possible.

In the more extreme cases of general rachitic deformity of the lower extremity in which the tibia is implicated, in addition to the femoral osteotomy it may be necessary to remove a cuneiform section of bone from the inner side of the tibia just below the epiphysis. In such cases it is better to perform the second operation at a later time in order that the effect of the first procedure may be observed.

Osteoclasis.—Osteoclasis by means of the Grattan osteoclast is, from the standpoint of the result, an equally efficient treatment. With this instrument the bone may be broken above the condyles at the desired point.

The adolescent type of genu valgum is not often extreme, and as a rule the distortion of the bone is comparatively slight, the deformity being exaggerated by laxity of ligaments and by the habitual attitude. In the more chronic cases osteotomy above the condyles may be performed in the manner described, but in Berlin and Vienna where the deformity is more common than in New York, other procedures are often employed.

One method is that of Wolff, who by means of the "Etappen Verband," gradually corrects the deformity.

The patient is anæsthetized, and the limb having been carefully protected with cotton, particularly about the malleoli, the patella and the inner condyle are enveloped in a firm plaster bandage reaching from the malleoli to the pubes. When the plaster begins to harden one assistant steadies the pelvis, another holds the inner condyle, while the operator draws the leg inward with moderate but persistent force against the fulcrum formed by the hand of the second assistant and holds it firmly in the partly corrected position until the bandage is hard. About three days later a wedge-shaped section of the bandage, about one inch in width, is removed from the part that covers the inner half of the knee, the other half of the bandage being simply divided. The leg is then forced inward until the two sections are again brought into contact. The position is retained by an additional plaster bandage about the weakened part. This procedure is repeated at intervals until the leg is completely straightened, a result that is often accomplished in a few weeks. No anæsthetic is required for the secondary treatment. When the deformity has been corrected the patient is allowed to walk about, and for convenience the plaster bandage is divided into a thigh and leg part, which are attached by lateral joints incorporated in the substance of the plaster, so that movement is allowed. This apparatus must be worn for several months, and is of course to be supplemented by massage and exercises.

Another means of correction of deformity without open operation is that employed by Lorenz, what he calls "Intraarticuläre modelirende Redressement." In this operation the deformity is reduced under anæsthesia at one sitting, by the gradual application of force by means of his osteoclast. The distortion is corrected partly by stretching the external ligaments and partly by straightening the bones. A plaster bandage is worn for six weeks when it is replaced by a jointed brace. As a rule, the patient is alowed to walk about in a few days after the operation. *Royal Whitman.*

KOLA (or **COLA**) **NUT.**—(*Semen Kolæ* or *Colæ; Guru* or *Gooroo Nuts; Bichy* or *Bissy Nuts; Soudan Coffee.*) The fresh or dried cotyledons of *Cola vera* Schum. or of *C. acuminata* (Beauv.) Schott. (fam. *Sterculiaceæ*). These plants are medium-sized trees of western tropical Africa, cultivated there and elsewhere in tropical regions and extensively naturalized in the West Indies. The commercial product is obtained from both cultivated and wild trees and both from the West Indies and from Africa. The seeds grow from one to three in each of the four to eight cells of a large woody capsule, the cells of which split open at maturity. The seeds possess a thick, softish testa, which is allowed to soften by partial decay for some days, when it is removed. The cotyledons, two in the first-named species, three or four in the second, constitute the whole of the kernel. This kernel is very thoroughly washed in the purest of water. If to be exported in an undried condition, those which are still entire are then enwrapped in the large leaves of a related species, and packed carefully in baskets. If kept carefully, they will remain fresh for many weeks and, thus imported, they constitute our "fresh kola." Otherwise, they are dried in the sun, when the cotyledons usually separate. There can be little doubt of the greater activity and superior properties of the undried kernels.

For native consumption, they are used entirely in the fresh condition, and are mostly caused first to enter the incipient stage of germination. Opinion differs as to whether this operation changes them only by a sweetening process, due to the conversion of some starch into sugar, or whether, as claimed by the natives, their nervine action is thus increased.

Description.—The fresh kernels are irregularly oblong, or ovoid, somewhat inclined to be bluntly angled, slightly compressed one way, usually with a slight fissure indicating the division of the cotyledon; about one to one and one-half inches long, not quite so broad and about two-thirds as thick. The surface is smoothish, somewhat granular, the color purple to brown, the texture tough-fleshy, the odor somewhat aromatic, the taste aromatic, bitterish, and astringent. In the dried condition, the above bodies are mostly separated into halves, reduced about a third in size by drying, each somewhat bent, thus becoming irregularly plano-convex, or the flat side even a little concave. The edge is thin and quite sharp, the color dark-brown, the outer surface granular, the inner smooth, the consistency hard and quite tough. They have almost no odor and the bitterness and aroma are nearly lost, the astringency being mostly retained.

Constituents.—Much effort has been bestowed upon attempts to determine the presence of constituents which can explain the remarkable statements which have been made concerning the effects of the native use of kola, but, as usual in such drugs, these constituents, if they exist, are elusive. Besides about one-tenth per cent. of volatile oil, forty per cent. of starch, and from two to four per cent. of tannin, the important constituents are alkaloidal, to the extent of about two to four per cent. A very slight amount of this alkaloid is theobromine, the remainder caffeine. About half of this caffeine exists free, the remainder combined with the tannin (*kola-tannin*) as *kolanin.* Although the latter compound is said not to be a glucoside, yet it is decomposed by a special enzyme, after the manner of glucosides in seeds. A peculiar coloring matter, *kola red,* is also yielded.

Action and Uses.—Kola is to the native of Africa what coca and maté are to the South American, and marvellous tales are told of the amount of work and fatigue that the African is enabled to endure when supported by the stimulating properties of this seed. It has been held in the greatest esteem from time immemorial, and is now looked upon almost as a necessity.

In addition to its ordinary use, it has acquired a reputation as a specific in counteracting the depressing and debilitating effects of alcoholic intoxication. Experiments have been made with it in the French army which prove that it has decided stimulating properties, but is in no sense a food.

The kola nut and its physiological action were treated in a thorough manner by Dr. Monnet in 1884, under the direction of Dr. Dujardin-Beaumetz, and an abstract of his thesis was published in the *Therapeutic Gazette* in the following year. The physiological and therapeutic actions are summed up by him in the following conclusions:

1. Kola, by virtue of the caffeine and theobromine which it contains, is a tonic of the heart, whose pulsations it accelerates, while it increases its power and regulates its contractions.

2. A second phase of its action, similar to that of digitalin, proves it to be a regulator of the pulse, which revives under its influence, the pulsations becoming fuller, and less numerous.

3. In consequence of its action upon arterial tension, diuresis is increased, and, consequently, kola can be employed to good advantage in cases of dropsy with cardiac lesion.

4. It might be deduced from observation that kola, which acts energetically upon cardiac contractions, and upon the contractility of muscles of organic life, would, on the other hand, have a paralyzing influence upon the striated muscles, when it is used in toxic doses.

5. It retards tissue metamorphosis and diminishes the

excretion of urea resulting from decomposition of azotic substances, very likely by exerting a special action upon the nervous system.

6. It is a powerful tonic, through the principles which it contains, and its employment is indicated in cases of anæmia, in chronic affections associated with debility, and in convalescence from acute disorders.

7. It favors digestion, either by augmenting the secretion of the gastric juice (eupeptic), or by acting on the fibres of the stomach, which it would render less atonic in cases of dyspepsia. Under its influence, rebellious anorexia disappears and the digestive functions become more regular.

8. Finally, it is an excellent anti-diarrhœa remedy, and has rendered great service in chronic diarrhœa or sporadic cholera, although its action could not be explained physiologically.

It is to be noted that the above results were doubtless reached by the use of the dried kernels, in which the kolanin compound is in decreased amount. The question of the relative action of free caffeine, and of the same amount taken into the system in a combined state like kolanin, is an important one. It appears reasonable to suppose that there would be an important advantage in degree, if not in kind, if the latter method were employed; and reports must be judged differently, according to which of the two forms was employed.

Surgeon R. H. Firth publishes (*Practitioner*, July, 1889) some very practical observations made upon British troops and natives under his control, and concludes that kola is in no sense a food, and that its physiological action is explained by the contained alkaloids; when pure and not too old, it has a peculiar stimulant action upon the nervous system, temporarily strengthening the heart beat, and increases the arterial tension; taken continuously during times of exertion and fasting, it possesses some power of warding off the sense of mental and physical exhaustion. This power, however, is not so marked as some observers have reported; in the convalescence from long sickness, its value is not apparent, and its alleged antagonistic action to alcoholic sequelæ is not capable of proof.

The use of kola among pedestrians and athletes has gained some popularity and repute.

As a therapeutic remedy, it is of benefit in strengthening the weak heart, augmenting the general flow of blood and vascular tension, and promoting diuresis. Its tonic effect has also proved of benefit in disturbances of the nervous system and debility of the cerebro-spinal centres, and in the prostration accompanying and following severe fevers and protracted illness. As a remedy for diarrhœa, particularly of an atonic character, it has proved of decided value. The combination of the tannic acid and its tonic principles makes it of great service in this disorder. The preparations advised are the alcoholic tincture, the elixir, and the wine. The tincture is made by exhausting fresh kola with five parts of alcohol, and the wine by macerating the same proportions of kola in wine for a fortnight. The dose is from one to two or three teaspoonfuls three times a day. The elixir is prepared by diluting the alcoholic preparations with equal proportions of syrup.

Henry H. Rusby.

KOOSSO.—CUSSO. BRAYERA. "The dried female inflorescence of *Hagenia abyssinica* (Bruce) Gmelin. (fam. *Rosaceæ*)," U. S. P.

This is a large and handsome, very leafy tree, with downy twigs and very silky buds and young leaves.

DESCRIPTION.—Mass red-brown, hairy and minutely glandular, consisting of panicles varying from 25 to 40 cm. (10 to 16 in.) long, a sheathing bract at the base of each branch, and two rounded bracts near the base of each flower; calyx having a cup-shaped, hairy tube and bearing on its back a circle, resembling an outer calyx, of five thickish and rigid, spreading, obovate, purple-veined bracts, which are larger than the five thinnish, usually shrivelled and incurved, oval calyx lobes; petals five, delicate, whitish, oblong, much shorter than the sepals, caducous, hence often wanting in the drug; stamens aborted; pistils two, the one-ovuled, ovoid ovaries concealed in the calyx tube, shorter than the styles, which are exserted; stigmas broad, hairy; odor slight, agreeable; taste bitter, acrid, and nauseous.

Cusso in the form of loose flowers, usually largely staminate, should be rejected.

This tree is a native of Abyssinia, where it grows abundantly wild, and is also cultivated about villages and roadsides for ornament. Its medical use was also

FIG. 3094.—Koosso; Staminate Flowers Enlarged. (Baillon.)

introduced about 1850 from that country, where every third person is said to have tapeworm, and where it has been used for a century or more. The detailed description of the flowers and panicles given above covers its description as a drug. The whole inflorescence is taken at about the time of flowering and simply dried and packed. Sometimes it comes in bales or large cakes, but more generally it is tied in rolls somewhat smaller and shorter than the arm. The pistillate panicles are easily distinguished by their large epicalices and their reddish-brown color, and are known as "red koosso." The odor is slight, fragrant, and tea-like; taste bitter and disagreeable.

COMPOSITION.—By distillation with water, koosso yields a small amount of *essential oil*, to which its fragrance is owing. It also contains nearly one-fourth its weight of *tannic acid* and considerable *wax*, *resin*, and other common vegetable products. Its peculiar active principle, however, is a yellow crystalline substance, *kosin* (of Merck). It is tasteless, insoluble in water, nearly so in alcohol, readily soluble in chloroform and ether, as well as in alkalies, from which latter it may be precipitated by acids. Kosin is permanent in the air, and is unquestionably the principal tænicidal agent of koosso.

USE.—Koosso has long been a popular anthelmintic in its native land, and since its introduction here has ranked among the best with us. Its action appears to be directly toxic to the worm, and, until the introduction of the pelletierine from pomegranate bark, was not only one of the most sure to bring the bulk of it away dead, but the

FIG. 3095.—Koosso; Pistillate Flower and Section Slightly Enlarged. (Baillon.)

most certain also to disengage and remove the "head." In order to obtain the best result from this, as well as from any other anthelmintic, the intestinal canal should be well emptied of its contents by a moderate laxative—say twenty-four hours before administering the koosso;—then, for at least twelve hours previously, no food whatever, excepting a glass or two of milk, should be taken. The koosso may then be given, when the patient should be kept quiet for one or two hours after, in order to overcome the nausea or vomiting that may result. Two or three hours after the tænicide has been taken, milk or beef-tea may be allowed, and five or six hours later a solid meal. If the drug be given in substance or infusion

it usually acts as its own cathartic, in spite of the large amount of tannin, but if it fails to do so in six or eight hours a saline should be given. Koosso is especially to be recommended for the different varieties of tapeworm; for the round and seat worms there are better medicines. The dejections should be carefully examined for the body of the parasite; from two to five, or more, metres of its larger joints are always found; they mean nothing as to cure, since any brisk cathartic might bring them away, and unless its attachment or "head" is killed, it will certainly grow again. If this is found, the cure is effected, excepting in those cases, exceedingly rare in this country, where two contemporaries exist in the same bowel. As a general rule, if 10 or 20 cm. of the long, thread-like "neck," not more than a millimetre in diameter and without distinct joints, are seen, the "head" is destroyed and has probably escaped observation; such cases are generally cured. But it is not safe, unless the "head" has been actually seen, to make a positive assurance to that effect until eight or ten weeks have elapsed without any segments appearing in the fæces.

Administration.—A common and efficient method is to give a six-per-cent. infusion made without straining from the powdered drug, the patient being expected to stir up and swallow the dregs with the tea. A tumberful of this may be taken and repeated in an hour. The fluid extract (*Extractum Koosso Fluidum*) is another and less disagreeable preparation, but more infrequently used; dose from 15 to 30 c.c. (15 to 30 c.c. = ℥ ss. ad ℥ i.). Kosin may be given in doses of from 1 to 2 gm. with the same preparatory treatment. In England it is preferred to give ℥ ss.–i. of the powdered drug suspended in mucilage.

W. P. Bolles.

KRESAMINE.—See *Ethylene-Diamine* and *Trikresol.*

KRYOFINE—methoxy-acet-para-phenetidin, methyl glycollic phenetidin ($C_6H_4.OC_2H_5.NH.CO.CH_2.OCH_3$)—is obtained by heating phenetidin with methoxyacetic acid to 120°–130° C. It occurs in white crystals, soluble in 600 parts of cold water, in 52 parts of boiling water, and in alcohol, ether, chloroform, and oils. It is odorless and ordinarily tasteless, though its concentrated solutions are bitter.

This drug, which is a modification of phenacetin (acet-para-phenetidin), has been recommended by Eichhorst, Hass, G. F. Butler, Fasano, and others as a very efficient analgesic and antipyretic in neuralgia, rheumatism, influenza, etc. Claims are made that its action is less rapid than that of many drugs of the class, and that it has less tendency to produce depression and profuse sweating. However, excessive diaphoresis and even cyanosis have been observed, and there is no evidence that kryofine is any better or safer than acetanilid or phenacetin. It has been found by Ebstein in the urine in fifteen or twenty minutes after ingestion, disappearing in from six to eight hours. The dose is 0.15–1.0 gm. (gr. iiss.–xv.). Sixty grains have been given in twenty-four hours without bad results.

W. A. Bastedo.

KUMYSS. See *Milk.*

KYPHOSIS.—The term "kyphosis" is derived from the Greek κυφός meaning humpbacked, bent forward, and signifies of course, only a symptom, but one which is present in a number of conditions both of disease and of injury. It always refers to the spine, and, inasmuch as tuberculosis of the spine is the disease which almost invariably presents this symptom as its most conspicuous clinical feature, the term kyphosis is perhaps most generally supposed to refer to this disease. It always signifies an antero-posterior curvature.

We will consider the spinal column a moment from an anatomical point of view before taking up the pathological changes causing kyphosis. The column above the sacrum is composed of vertebræ which diminish in size as one approaches the atlas; these are separated by fibro-cartilaginous discs which equal one-fifth of the whole bony column in height and are more or less elastic and compressible. The vertebræ are kept in place by ligaments outside the vertebral canal as well as within the canal itself. These have some elasticity and allow motion of the vertebræ on their articular facets. In addition to the support afforded by the ligaments the column is maintained erect by the powerful spinal muscles, and in the lumbar region by a fibrous aponeurosis as well. When these anatomical features are present in a normal condition, under normal relations one to the other, then the column in the erect position presents certain normal physiologico-anatomical curves dependent chiefly upon where the centre of gravity passes through the column. In a normal individual this is as follows: A perpendicular line should pass through the odontoid process, and then through the body of the second dorsal vertebra; thence it should intersect the column at the tenth and eleventh dorsal vertebræ and then pass on down through the sacrum. It is important to remember this because a lack of familiarity with the normal curves of the spine and the variations which may take place in it within normal limits is the source of much confusion and oftentimes of positive wrong, particularly in medico-legal work. Certain vertebræ at the junction of the cervical and dorsal portions of the spine are invariably more prominent than elsewhere. Again, in the lower dorsal and upper lumbar regions there are also two or three spinous processes which are more conspicuous than their fellows, particularly in flexion of the column. Posture, occupation, etc., readily aggravate such conditions, when once they are present, as does also the lack of subcutaneous fat. There are also congenital defects in the spine which give rise to a bending forward of the column, or at least an apparent bending of it. The defects are most commonly in the cervical region and in the lower dorsal or the lumbar region. In the latter region occur the spinæ bifidæ; in the former, the meningo-encephaloceles.

1. To distinguish normal curves from pathological ones is not commonly difficult. The meningo-encephaloceles are the result of a failure of the posterior neural arches to unite, and a protrusion of the coverings of the cord ensues, either complete or partial. Many of these cases do not live longer than through the period of infancy, but occasionally, when the bony arch has not failed completely to unite, the patients survive and have a very short neck with high standing shoulders and considerable deformity. The spinæ bifidæ, which commonly occur in the lower dorsal or the lumbar region, are readily recognized by the soft and fluctuant character of the swelling, which is in the median line, and is accompanied usually by more or less paralysis of the lower extremities, both sensory and motor. The kyphosis is not due to alterations in the bone.

2. Trauma may cause kyphosis, and frequently does. Under this head come the fractures of the spine which are commonly accompanied by considerable deformity and by more or less paralysis below the deformity, both motor and sensory, involving the sphincters also. The bend is sharp, and involves as a rule only two or three vertebræ at the most. Dislocations of the spine cause kyphosis frequently. They are more common in the cervical region. They are not apt to cause as complete paralysis as do the fractures, and they are amenable to treatment. Another sort are the so-called "torsions," or ruptures of spinal ligaments in which there is more or less motor and sensory disturbance below the seat of injury; a kyphosis is present on flexing the trunk, with an aggravation of the above-mentioned symptoms, which disappear, as does also the kyphosis, when the trunk is hyperextended. This kyphosis manifests itself in the form of a sharp bend involving two or three vertebræ.

3. In young children with acute rickets a kyphosis is very common. This curve is a long sweeping one, involving pretty much the entire dorsal portion of the column, but is not accompanied by muscular spasm; the curve disappears entirely on hyperextension of the trunk, and the child commonly presents the other evidences of acute rickets; viz., pain on handling; enlarged epiphyses; rosary; prominent abdomen, etc.

4. Osteo-arthritis frequently attacks the spine and causes antero-posterior deformity. This occurs most often in adults, usually men. The forward and backward motions of the spine are restricted; the kyphosis involves several of the vertebræ and is produced by the lipping of the cartilages about the vertebral bodies, and this lipping is so situated on the anterior portions of the vertebral bodies that the complete flexion and extension of the spine is limited. These deposits are analogous to Heberden's nodes in the terminal phalanges of the fingers.

5. Rheumatoid arthritis seldom attacks the spine, but when it does it causes an atrophy of the intervertebral discs, as a result of which the spine manifests a long sweeping curve, which cannot usually be corrected without pain and spasm. Other joints invariably manifest the characteristic lesions. It is a disease of young adult life, and, so far as it involves the spine, is apparently more common in men.

6. Osteitis deformans, or Paget's disease of bone, is a disease of late adult life, occurring in men usually and resulting in an antero-posterior flexion of the whole spinal column together with considerable thickening and bowing of the long bones. The column becomes usually completely ankylosed. The kyphosis shows itself in these cases in the form of a long sweeping curve.

7. Osteomalacia, most often seen in women in adult life and during the parturient state, causes occasionally a kyphosis. As a result of the slow softening which takes place in the bony structures of the spinal column in this disease the latter gradually assumes a moderately pronounced degree of curvature—one quite different from the sharp bend that follows the inflammatory type of bone disease. At the same time evidences of the same morbid process will be observed in other bones of the body.

8. By far the greater number of antero-posterior curves in the spine are caused by tuberculosis (Pott's disease). In these cases the spine becomes sharply bent, during the active stage of the disease, at some one point, owing to the fact that at this time only one or two vertebræ are involved. The disease is most common in childhood, and is about equally distributed as to sex. It may involve any part of the spinal column, but is most common in the dorsal, somewhat less so in the lumbar, and least common in the cervical region. It cannot be obliterated by hyperextension, and is accompanied by muscular spasm in the spinal muscles at the seat of the disease. It is by no means uncommon in adults, either as an acute or as a chronic process, as late as middle life. It is usually slow in development.

9. Acute osteomyelitis attacks the spine not infrequently. It is acute in onset and may follow some septic process such as tonsillitis or other infectious disease. It causes some kyphosis, though not the acute bending of the spine that is observed in Pott's disease. There is much pain, chiefly local in character, and considerable fever is present. In most cases suppuration takes place and sequestra are formed. The whole course is much shorter than in Pott's disease, and the deformity is much less and is due more to muscle spasm than to destruction of vertebral substance.

10. Malignant disease, both carcinoma and sarcoma, is said to occur primarily in bone, but is much more commonly secondary to malignancy elsewhere—usually the breast or the intestine. The bend in the spine is generally of small size, and is due to the destruction of the bone trabeculæ by the cancerous infiltration. The most striking feature is the great pain of which these patients complain. The disease develops slowly and is characterized by marked cachexia, and the peripheral sensory disturbances predominate over the peripheral motor disturbances, the reverse of the condition seen in Pott's disease. Malignant disease occurs in adults and rather more frequently in women than in men.

Sarcomatous kyphoses may be both primary or secondary, the latter usually following sarcoma in the liver. They occur in childhood most commonly, and are more rapid in development than those due to carcinoma.

11. Occasionally the muscular dystrophies, by causing a sharply limited muscular atrophy, give rise to an apparent kyphosis where the atrophy of the spinal muscles stops and the normal muscle commences. This ought to cause no difficulty in diagnosis, as the atrophy which could possibly cause any such confusion is usually confined to the scapular group of muscles and the spinal muscles in the immediate vicinity, and the atrophy and loss of power in the scapular groups would show clearly the diagnosis, aside from the absence of other spinal symptoms.

12. In this same category we have infantile paralysis, involving the trunk muscles and causing a long sweeping curve in the spine with prominence of several spinous processes. The patients are unable to sit erect, and, besides the history of infantile paralysis and the usual presence of paralysis elsewhere—*e.g.*, in the extremities, the muscles being flaccid,—there is abnormal mobility in the spinal column in all directions, with entire absence of muscle spasm.

13. Certain functional conditions in the region of the spine may also cause a kyphosis. They are associated, as a rule, with the neurasthenic state, but sometimes they are simply the result of the loss of muscular tone in rapidly growing children, particularly girls, or in patients who are convalescing from pregnancy or from some acute disease. Finally, they are also observed in the blind as a result of an habitually faulty posture. The curve observed in such cases is of the long, sweeping character, and may easily be corrected by suitable manipulations. It is not accompanied by spasm, but in the neurasthenic it is frequently associated with hyperæsthesia along the spinous processes.

Under this functional head should be included the hysterical curvatures.

14. Syphilis. The tertiary manifestations of this disease are occasionally seen to cause an antero-posterior curvature of the spine. The character of the bend in the spine and the symptoms which occur differ but little, if at all, from those seen in Pott's disease, and the history must be chiefly relied upon for establishing the diagnosis. These cases will respond to antisyphilitic treatment, and they are less apt to be accompanied by a cold abscess.

15. Typhoidal, Gonococcal, and Post-Scarlatinal Kyphosis. In the kyphoses which are due to these diseases the absence of any protrusion along the course of the spine or of any suggestive symptoms, prior to the onset of the acute disease, must first of all be established. The deformity in these cases develops much more rapidly than it does in other forms of the disease; furthermore, the first evidences of the change are usually observed during the acute stage or at least early in that of convalescence. The entire course of the disease is of much shorter duration than it is in any of the other forms of kyphosis. The results obtainable from treatment are also apt to be better.

16. Mollities Ossium, Hydatids, Actinomycosis, and Aneurisms.

A very rare cause for kyphosis is the process of bone softening known as mollities ossium. This occurs more commonly in children than in adults, and the spinal column is just as liable to be affected as are any other parts of the bony framework. The fact that the softening rarely if ever affects any one part of this framework alone should aid one materially in making the differential diagnosis.

The presence of hydatids, forming cysts in the vertebral bodies, is extremely rare, but has occurred. A correct diagnosis can of course be made only after the discovery of the hooklets in the contents of the opened cyst.

Of about equal rarity is the occurrence of actinomycosis as a cause for kyphosis; this also could be demonstrated as the cause only by finding the fungus in any pus coming from the spine of a patient thus affected.

The pressure made by an adjoining aneurism may cause erosion of one of the vertebral bodies and thus lead

to a kyphosis having an antero-posterior curve. The pain, while this process is going on, is very severe. Such cases occur almost always in middle adult life, and careful examination at repeated and short intervals may clear the diagnosis.

The foregoing, in brief, are the principal causes for kyphosis.

The nature of the process that gives rise to a bony kyphosis must be determined through a consideration of (*a*) the history, (*b*) the duration, (*c*) the onset, (*d*) the presence or absence of muscular spasm, or of bony ankylosis, (*e*) the presence, either immediate or remote, of diseases elsewhere in the body which, if present in the spine, would cause a kyphosis, and lastly (*f*) the presence or absence of paralytic conditions in the spinal muscles. *Charles F. Painter.*

LABIATÆ.—(*The Mint Family.*) A very large family of more than one-hundred and fifty genera and about three thousand species, growing in almost all parts of the world. The constituents and properties of these plants are so uniform, and so important, that their recognition is highly desirable. They have square stems, opposite, almost always aromatic, but not punctate leaves, the corolla usually, and the calyx frequently, bilabiate, the stamens two, or four, and didynamous, the ovary two-carpelled and maturing in the form of four one-seeded nutlets. The last character distinguishes them from the closely related Scrophulariaceæ, which are frequently poisonous, while the Labiatæ never are. These plants are often exceedingly showy. Their only other value resides in their almost invariably aromatic properties, due to the presence in them of volatile oils. The mints, lavender, rosemary, pennyroyals, thyme, and various others of the class are treated in this work in their proper order. A host of others, some treated in the previous edition of this work, might be enumerated. Some of those more commonly used are the sweet marjoram (*Origanum Majorana* L.), summer savory (*Satureja hortensis* L.), dittany (*Cunila Mariana* L.), hyssop (*Hyssopus officinialis* L.), *Ajuga*, *Cedronella*, various species of *Monarda*, *Kaellia* (*Pycnanthemum*), *Calamintha*, and *Orthosiphon*. Others contain a bitter substance also, and are used as aromatic bitters. Representatives of this class, treated in this work, are horehound and sage. Those of minor importance, of the same class, deserving of mention, are wild origanum (*O. vulgare* L.), glechoma or ground ivy (*Glechoma hederacea* L.), germander (*Teucrium Chamædrys* L. and various other species of *Teucrium*), motherwort (*Leonurus Cardiaca* L. and other species of *Leonurus*), many species of *Mesosphærum* (*Hyptis*) and *Ocimum*, and several of *Lamium*, heal-all or *Prunella* (*Brunella*), *Lycopus*, or bitter bugle and *Scutellaria* or skull-cap. Occasionally these plants, as in the case of salvia, combine a considerable amount of tannin with their volatile oil and amaroid, and have distinctly astringent properties. *Henry H. Rusby.*

LABOR, NORMAL, MANAGEMENT OF.—The ability properly to manage a normal case of labor is one of the most essential features in the armamentarium of the practising physician, and occasions for showing this ability will confront every medical man before he has been long in the field. To the student or young practitioner in attendance upon his first case of labor there is much that is embarrassing and calculated to disturb his equanimity. The intimate relation in which he is thrown in contact with the patient, the necessity for making examinations that are revolting to every woman, his painful consciousness of his own lack of experience, and the fact that there are present bystanders who possess the very thing that he lacks, namely, practical experience, all conspire to make his position an embarrassing one. Some consolation may be found in remembering that labor is a physiological process, which, if left absolutely alone, will result in a large percentage of the women being safely delivered. And unless certain definite indications manifest themselves, an attitude of watchful inaction is better than one of meddlesome interference. On the other hand, it must be borne in mind that, although a physiological process, there are many emergencies which may arise, in the course of a seemingly normal labor, the proper recognition and treatment of which will either save the life of the child or mother, or forestall years of chronic invalidism on the part of the latter.

The most important complication arising from the improper management of a case of labor is infection, and it may be said here that the principal directions given as to the method of conducting a case will be for the purpose of avoiding this unfortunate result. Before the time of Listerism the mortality of childbed was from two to ten per cent., and in certain epidemics very much higher (Jewett, "American Text-book of Obstetrics," first edition). In some of the lying-in hospitals in those days the mortality was frightful, and according to Williams ("Practice of Obstetrics by American Authors," Jewett, second edition) the frightful mortality occurring in such institutions attracted the attention of the public at large, and steps were being instituted to abolish them as a menace to public health. In 1880, when Pasteur (*Bull. de l'Acad. de Méd.*, 1879) discovered that streptococci were present in large numbers in the bodies of women who had succumbed to puerperal fever, observers began to realize that this disease was analogous to a surgical infection and, in a great measure, preventable.

In no branch of medicine have the results of antiseptic surgery been so markedly shown as in obstetrics, and the mortality which before 1880, as has been said, was from two to ten per cent., at once dropped, so that at present a septic death in a well-organized lying-in hospital is an exception, and various authors have cited statistics based on many thousand cases in which the septic mortality was only 0.25 per cent. A graphic example of this kind came to the notice of the writer only a short time ago, while looking over the records of the Maryland Lying-in Asylum in Baltimore. Of 100 cases that were delivered in 1879, 42 of them had a temperature above 102° F. during the puerperium; while in the past three years, 1899, 1900, and 1901, there has been only 1 septic death in about 400 cases.

Although the large clinics have profited by the advent of antiseptic surgery, the same cannot be said of the results of the general man. This is unfortunate, but it is nevertheless true, and can be explained by the simple statement that the average practitioner in medicine either does not know how to, or will not, practise an aseptic technique. The truth of the statement just made is evidenced by an article which was published a few years ago by Reynolds, of Boston (*Boston Med. and Surg. Journal*, cxxxi.), who in 1893 attempted to write an article upon the prevalence of puerperal fever in that city. On looking over the records furnished by the health office he found, if such records were diagnostically correct, that in his own practice he had seen more than one-fourth of all cases of puerperal fever that occurred in Boston in that year; a thing obviously ridiculous, but probably due to the fact that the laity, knowing the nature of puerperal infection, were wont to put the blame on the physician in charge, who to avoid this reproach reported such cases as typhoid fever, pneumonia, and such like. Bacon (*American Gynæcol. and Obstetrical Journal*, 1896), in an article based upon the health records of Chicago, says that puerperal infection still played a very prominent part in the death list, and, according to Boxall (*The Lancet*, 1893), the lessened mortality of childbirth since 1880 is not so much due to the lack of puerperal infection as to better and prompter application of operative procedures, and he makes the statement that in the rank and file of the profession outside of lying-in hospitals the results are as bad to-day as they were twenty or even forty-five years ago. Garrigues ("American Text-book of Obstetrics," first edition) makes the following statement: "The hospital is now the safe place for a woman to be delivered in; it is in private dwellings that danger lurks. The poorest, the dirtiest, the most dissolute women are safely confined in a hospital; the richest, the youngest,

the purest, and the loveliest sometimes succumb in giving birth to a child in their own homes."

Such being the case, it then becomes more than the duty of every medical man to practise to the best of his ability an aseptic technique in the management of labor cases. In private practice this is sometimes not an easy matter. While in the hospital, the resident physician sees no septic cases, everything that comes in contact with the parturient undergoes a rigid sterilization, and at the time of the labor there is no lack of assistants to maintain the aseptic technique, on the other hand, the patient delivered at her home is in the hands of a general practitioner who may have in the next house a case of erysipelas, sterilization is difficult, and at the time of the labor he has no assistance save that which is rendered by a very inefficient nurse. Again, in private practice the obstetrician may be led, by his sympathies for the patient and by requests of members of her family, to do something contrary to his better judgment.

So much for the general principles which govern the management of labor. In what is to follow, little will be said as to the management of labor in hospitals, as in many of these institutions the technique is beyond reproach, but we will turn our attention to the management of labor in private practice, for here, unfortunately, there is room for vast improvement. We will consider the subject under two heads, namely: The Care of the Patient before Labor, and The Actual Management of the Labor.

The Care of the Patient before Labor.—(*a*) *The Obstetrical History.*—When a patient engages a physician to look after her in an expected confinement he should take a complete history of the case. Many physicians have specially printed blanks for this purpose, among whom may be mentioned Ayers and Edgar, of New York, Hirst, of Philadelphia, and Williams, of Baltimore. While such a method of keeping records is simple and easy it is not absolutely essential, and any history carefully preserved will be not only of the greatest help at the time of the labor, but also valuable legal evidence if any occasion for it should arise. The form of the history is not important, but it should be recorded so as to contain the following data: name, age, race, and condition of patient; *marital history:* how long married, if the present is her first or second marriage; the number of miscarriages, length of time in bed after each; important sequelæ, if any; previous labors, whether normal or abnormal, and if abnormal, how delivered and why; condition of the children at birth and at present. Important information may often be obtained by the thorough investigation of a previous difficult labor. *Menstrual history:* age of first menstruation, frequency, duration, and amount of pain and discomfort, date of last menstruation, from which can be deduced with reasonable accuracy the date of expected confinement. *Family history:* here any possible hereditary tendency is investigated. *Personal history:* this should contain a complete medical summary of the ailments from which the individual under consideration may have suffered with special reference to diseases that result in heart or kidney lesions, for example acute rheumatism and scarlet fever, together with those diseases of the bony skeleton which result in the production of deformities of the pelvis, namely, rachitis, osteomalacia, coxalgia, spinal curvature, etc. *History of the present pregnancy:* supposed date of conception, amount of nausea in the early months, date of first perception of fœtal movements, symptoms attributable to renal insufficiency, such as headache, disturbance of vision, œdema, epigastric pain, and finally any other symptoms of importance that the patient may suggest.

If such a history be taken in every case the obstetrician will find himself in possession of information which will later be of great value to him. The mistake is often made in considering labor purely a local process, and the operator is thunderstruck to find a pre-existing heart or kidney lesion of which he had no suspicion causing serious trouble. The history should be taken as soon as practicable after the physician has been engaged, and the patient should be seen at regular intervals from then until the time of labor. If the history indicate no abnormality, a physical examination is not necessary until shortly before the date of expected confinement, but, if such be not the case, any suspecte dabnormality should at once be investigated.

(*b*) *Urinalysis.*—The importance of regular systematic examinations of the urine in a pregnant woman cannot be overestimated, for it is by this means only that we have a warning of one of the most frightful complications of late pregnancy and labor, namely, eclampsia. It is the habit of the author to examine the urine of every patient in his care at least once a month in the early months of pregnancy, and every two weeks from the sixth month on. If symptoms suggestive of renal insufficiency occur at any time except those above mentioned, the urine is of course at once examined, and in this way an albuminuria can be detected shortly after its onset. The routine of urinary analysis should be as follows: general appearance, color, and odor; reaction and sediment; specific gravity; albumin present or absent, if present, in what quantity (Esbach's picric-acid test); sugar, present or absent; microscopic examination with special reference to the presence or absence of tube casts.

The significance of albuminuria in a pregnant woman is of importance only to direct our attention to other more grave symptoms. It is a very common occurrence in a pregnant woman, according to Williams of the Johns Hopkins Medical School (personal communication); albuminuria occurs in 50 per cent. of 1,000 cases, albumin and casts in 7.3 per cent. In 200 cases delivered in the last year in the Maryland Lying-in Asylum, 38 had albuminuria and 3 albuminuria and casts. The difference between these two series of figures is probably due to the fact that the specimens of Williams were all voided, and the faintest trace of albuminuria was noted, while in those of the Maryland Lying-in Asylum only catheterized specimens were used, and a very faint cloud on boiling was not noted. It is usually considered that a trace of albumin without casts is of little significance, and in such cases, if the urine be examined again in a few days, the albuminuria will be found to have disappeared. If, however, it is in larger amount and associated with casts, one should at once investigate the nitrogenous elimination of the patient as indicated by the amount of urea. The best method of doing this is by the ureometer of Doremus, in which 1 c.c. of urine is introduced into a fermentation tube containing a standard solution of hypobromite of soda, and the resulting nitrogen read in the graduations of the tube. It is essential in this test that one should know in cubic centimetres exactly how much urine is being passed in twenty-four hours, and to do this a cubic-centimetre graduate may be left at the patient's house with directions that she measure all urine passed and send a mixed specimen to the doctor in the morning. If the amount of the urea per diem is found considerably below normal, 22 gm., she should at once be put on a milk diet and eliminative treatment, and a daily examination of the urine should be made. It is by this method only that we have a criterion as to the proper treatment and the condition of the patient in cases of suspected eclampsia; any increase in the urea indicating an improvement and any decrease the opposite.

(*c*) *The Preliminary Examination.*—This examination should be made in a case in which abnormality is not suspected about four weeks before the expected delivery. If, however, there is any reason to suspect the existence of any pelvic deformity, an examination had best be made not later than during the seventh month. In this latter instance, of course, it will have to be repeated later in the pregnancy. When the obstetric history was spoken of, attention was called to the fact that a general history was of the greatest importance. The same may be said of the examination, and the operator must not simply turn his attention to the genital organs, but make a critical study of the entire patient. It is always best to have a regular routine for such an examination, and the following is suggested: heart and lungs, breasts, general develop-

ment of bony skeleton, abdomen, pelvimetry, and the vaginal examination.

Heart and Lungs. Little need be said in this connection, as any one familiar with ordinary chest diagnosis will be thoroughly able to conduct the examination. As regards the heart, if a murmur be noted that is thoroughly compensated, in the great majority of the cases a good prognosis may be given. Exception must be taken, however, to mitral stenosis, as this is the lesion most likely to give fatal results. It has been erroneously supposed that pregnancy affords an immunity to pulmonary tuberculosis. This is due to the fact that tuberculous patients invariably do well during pregnancy. If, however, tuberculous disease of the lungs be found, the case should be watched with the utmost care, as it is not an uncommon occurrence for the disease to take on a much more acute form after the pregnancy is over. Lusk, quoting Spiegelberg ("Lehrbuch der Geburtshilfe"), says it often happens that women with inherited tendencies to phthisis may escape during their first pregnancy only to become its victims in a later one, and out of twenty-seven cases of phthisis collected by Grisolle (*Arch. gén. de méd.*, vol. xiii., cited by Playfair) the entire duration of the disease averaged only nine and a half months.

The Breasts. The breasts will be found to present the pigmentary changes characteristic of pregnancy, and note should be made of the condition of the nipples. It is frequently possible by proper treatment of the nipples instituted at this time to make a mother able to nurse the child who otherwise could not. In addition to this, the presence or absence of colostrum should be noted, as also the size and consistency of the gland, together with any abnormality.

Since Williams ("Obstetrics," vol. i., Nos. 5 and 6) has shown that contracted pelves occur in 13.1 per cent. of all American women, one of the most important steps in the examination of a pregnant woman is the *inspection of the bony skeleton* in order to ascertain the possible existence of a deformed pelvis. Of particular importance is this when we are dealing with the negro race, for in this class of patients Williams has shown that contracted pelves occur in 19.83 per cent. Points to be ascertained are the presence of signs characteristic of rachitis, such as the peculiar development of the cranial bones, the rachitic rosary, the "sabre-shaped" tibia. Again, any curvature of the spine should be noted, the most important being a kyphosis; and finally, search should be made for ankylosis of one or both hips, or for inequality in the length of the legs from any cause. It is frequently of great assistance in this connection to view the patient in the erect posture, for by this means a lateral asymmetry of the body is best seen.

Abdominal Examination. The abdominal examination is the most important of the various steps. Note should be made of the size of the abdomen, the position, consistency and general feel of the uterine tumor, the distance of the fundus from the ensiform cartilage, and, above all, the position and presentation of the child. The fœtal heart, uterine and funic souffle together with movements of the child, can be heard on auscultation; the location of the former giving us important information as to the position and presentation of the fœtus.

The diagnosis of position and presentation is such an important subject as to justify a little space being devoted to it alone. The examination is conducted with the patient lying on her back on a hard bed or examining table, the head and shoulders slightly elevated and the legs slightly flexed so as to relax the abdominal muscles. The abdomen should be bare, or covered with a very thin sheet. The best results are obtained if the operator has a regular method of procedure, and, in the opinion of the author, by far the best is that devised by Leopold and Credé ("Die geburtshilfliche Untersuchung," Leipsic, 1892), which is as follows: The method consists of four manœuvres; in the first three the operator faces the patient's head, and in the last one he faces her feet. (1) With both hands the operator palpates the fundus uteri, and by this manœuvre notes height of fundus and character of fœtal parts in this portion of the uterus. If it be breech, he is dealing with a presentation of the head, and if it be head, with a presentation of the breech. (2) Still facing his patient's head he palpates with both hands the sides of the uterus and notes the hard, resistant plane of the back on the one side, and the irregular nodulation of the small parts on the other, according to the position of each; the presenting point is on the right or left side as the case may be, and is directed anteriorly, posteriorly, or transversely according as the back and the small parts are felt with unequal or equal distinctness. (3) Maintaining the same relative position he grips with that hand which is nearest to the patient the lower uterine segment between his thumb and fingers and notes the character of the part of the fœtus at the pelvic brim. He can also tell by this manœuvre whether or not it is engaged in the pelvis. (Note that this manuœvre is complementary to the first.) (4) Turning so that he faces his patient's feet, and placing a hand on either side of the lower portion of the uterus, he presses the finger tips as deeply as possible into the pelvic brim, confirming his opinion as to the nature of the presenting part. If it be the head, he follows it with his finger-tips upward and notes on which side of the body of the mother it is most prominent. This location of "cephalic prominence" will tell him whether the head is flexed or extended; if flexed, the cephalic prominence is on the side of the small parts, and if extended, on the side of the back.

By this method it is always possible to make a diagnosis of the presentation and position of the child in the last three months of pregnancy. It is far superior to vaginal diagnosis, for this is not possible until the cervix is completely dilated and the head well in the pelvis. The advantage of the knowledge obtained thereby is obvious. If a malpresentation be diagnosed, means can be instituted during the latter months of pregnancy to correct it, or, if this be impossible, the physician is better able to cope with the abnormality when the patient goes into labor.

Auscultation of the fœtal heart gives valuable information not only as to the existence of pregnancy and life of the child, but also as to its position in the uterine cavity. To hear it, requires a certain amount of practice, but when the ability to do so is once achieved its value is inestimable. According to Palmer ("Amer. Text-book of Obstetrics," first edition) it was first heard by Mayer, of Genoa, in 1818, and, according to the former, it cannot be heard earlier than the fifth month. In the opinion of the author, however, it is almost impossible to do so before the sixth. In occipito-iliac presentation the sounds are transmitted to the ear of the examiner through the back of the child and lie below the transverse line running through the umbilicus. In face presentations, as the ventral surface of the child is in apposition with the uterine wall, the sounds are best heard at the point where the thorax comes in contact with the uterus. In breech presentations the sounds are also transmitted to the back, but here they lie above the umbilical line. If this be borne in mind, the diagnostic value of this procedure is evident.

Pelvimetry. In a case in which the existence of a pelvic deformity is not suspected it is only necessary to make a few routine measurements of the pelvis. That this is necessary, however, is shown by the fact that before the first article on the occurrence of pelvic deformity in this country was published by Williams in 1896 (Bulletin of the Johns Hopkins Hospital, August, 1896), American obstetricians were of the opinion that pelvic deformity among American-born women was of greatest rarity. Williams contended, however, that the condition was only rare because it was not systematically sought for by routine pelvimetry, and in the first hundred cases which formed the basis of this paper he was able to show that fifteen women had pelves the measurements of which fell below the normal standard. In several articles that have appeared since then by Williams and the author (Williams, "Obstetrics," vol. i., Nos. 5 and 6, and "American Medicine," 1901; and Dobbin, *American Journal of Obstetrics*, vol. xxxvi., 1897) the premise put forth by

Williams in his first paper has been definitely proved, and the last report, based on several thousand cases, shows that about thirteen per cent. of American women have contracted pelves. This being the case, the necessity for routine pelvimetry is obvious.

The measurements taken should be the distance between the iliac spines, the distance between the iliac crests, the distance between the trochanters, and the external conjugate or Baudelocque's diameter, and they should measure 26 cm., 29 cm., 31 cm., and 19.5–21 cm. respectively (Hirst). Of course these measurements are subject to a certain amount of variation, but the figures given are those for a woman of average muscular development. The first three are best made with the patient lying on her back, by means of a Martin's pelvimeter. The instrument is opened and its limbs are held between the finger and the thumb of either hand. The anatomical points mentioned are found and the distances between them read off the scale of the instrument. In measuring the interspinal diameter care should be taken to apply the points of the instrument to the outer edge of the bony spine. The Baudelocque diameter is measured with the patient lying on the side, one limb of the pelvimeter being applied to the most prominent portion of the symphysis pubis, while the other is applied to the depression below the spine of the last lumbar vertebra. In a symmetrically developed woman these measurements are all that is necessary, but if the history of examination indicate the existence of one of the rarer or asymmetrical forms of deformity special measurements for the classes of pelves under consideration should be taken (see article on *Pelves, Deformed*).

Vaginal Examination. In the latter part of pregnancy, when the diagnosis of the condition by abdominal examination offers no uncertainty, vaginal examination is not necessary unless indicated by the probability of a pelvic deformity. The indication will be found in the measurement of the Baudelocque diameter, which serves to indicate the probability or improbability of pelvic contraction. Hirst (*loc. cit.*) says: "An external conjugate of 16 cm. or under means certainly an antero-posteriorly contracted pelvis; between 16 and 19 cm. the pelvis will be contracted in more than half the cases; between 19 and 21.5 cm. there will be but ten per cent. contracted pelves, and above 21.5 cm. it is almost certain that the conjugate diameter of the pelvic inlet is not contracted at all." It is thus seen that when this measurement is above 19 cm. there is little or no necessity of subjecting the patient to the embarrassment and increased risk of an infection of a vaginal examination.

When the examination is made, with the single exception of the condition of the cervix uteri and engagement of the presenting part, there is little of importance except a thorough exploration of the bony pelvis. The examination, when made in the last month of pregnancy, should be done with the strictest antiseptic precautions, for one can never tell how soon labor may set in. The following points should be noted: condition of external genitalia and perineum, size of the vagina, character of vaginal secretion, position and condition of cervix uteri and presenting part. Bony pelvis: Inclination of pubic rami, width of interpubic angle (this should normally be a right angle with 45° on either side of the median vertical); condition of the ischial tuberosities; position and size of ischial spines, which can be felt by allowing the tip of the examining finger to travel from the anterior surface of the sacrum laterally along the sacro-sciatic ligament until the tip of the spine is reached; anterior surface of the sacrum, which should normally be concave from above downward, and concave from side to side; it should be palpable in the normal pelvis only in its lower third; palpability of the promontory of the sacrum and the measurement of the distance from this point to the lower margin of the symphysis pubis. This is the conjugata diagonalis and in the normal pelvis measures from 12.5 to 13 cm. The measurement is made by placing the tip of the middle finger on the promontory, and, with the index finger of the other hand, the point where the lower margin of the symphysis impinges on the hand already in the vagina is marked, and the measurement made by means of the pelvimeter from this point to the tip of the middle finger. The final step in the examination is the examination of the coccyx, which can be felt between the tip of the first finger in the vagina and the thumb upon the perineum behind the anus. Its size and mobility can thus be tested.

After having completed the examination the physician will be asked by the patient or some of her friends for a prediction as to the probable course of the labor, and in giving an opinion on this subject he must not forget that obstetrics is the branch of medicine in which emergenies are most frequent, and that a case with normal indications at the outset may present grave complications before it is over. If certain points be borne in mind a fair amount of accuracy can be obtained. If it is a primipara that is under consideration the factors that suggest a normal labor are her age, which should be between twenty-one and twenty-six, an occipito-iliac presentation of the child, a normal pelvis, and the absence of an intercurrent disease; if a multipara, to these factors we must add a normal history in previous confinements. In the presence of these conditions one can be justified in predicting a labor free from grave complications.

(*d*) *Preparations for Confinement.*—The preparations for confinement by the patient will vary in their extent according to her financial ability. If she is in moderate circumstances, she will probably expect her attending physician to supply everything that is needed except baby-clothes. If, on the other hand, she is in better circumstances, she will not object to having in the house at the time of her labor whatever her physician may direct. If the doctor is going to carry his own supply, very few directions need be given his patients. It is always well, however, to impress upon her mind the importance of having plenty of hot water, and, if he is going to use the permanganate-oxalic method of cleaning his hands, three or four basins will be necessary. If, on the other hand, the patient feels that she wants to have in the house the necessary drugs, supplies, and so forth, the physician can give her a list of such articles some time during the last month of her pregnancy.

The author has found it very convenient to have the articles in question put up in a compact case by one of the local druggists. The patient is then simply directed to buy a "confinement outfit," which contains the following articles: two pounds absorbent cotton; one pair leggings; one hand brush; two cards safety pins, assorted; one-ounce tube vaseline; four-ounce jar green soap; one bottle blue antiseptic tablets, S. & D.; one-half pound boric acid; eight ounces alcohol; one-quarter ounce ergotole; 100 gm. chloroform, Squibb's; eight ounces oxalic acid; four ounces potassium permanganate; six nurses' record sheets.

If the pregnancy is a first one she will need in addition to the above the following list, which is not included in the first, for the reason that women who have had more than one child usually have these articles in the house.

Additional articles should be on hand as follows: one piece rubber sheeting, one by two yards; one Eureka bed pan; three small agate basins; one fountain syringe, two quarts; twenty-five yards absorbent gauze; two pounds absorbent cotton; two cotton bats.

She or her nurse is instructed not to touch the drugs, but to make with the gauze and cotton a number of vulval and bed pads, the former being about nine by three inches, of which she should have several dozen wrapped in packages of one dozen each and sterilized, and the latter (the bed pad) a large square of cotton covered by gauze, say three by four feet, upon which she is to lie in the first few hours following delivery. In addition to this, she is to sterilize at least one-half a dozen napkins or towels for use at the time of labor. If the patient or a nurse has access to a regular steam sterilizer, the dressings can be sterilized in this; if this is not feasible, however, it can be done by wrapping the dressings neatly in towels, and baking them in an oven until the outer

covering becomes scorched. The nurse should also be instructed to have two pitchers of boiled water prepared and covered as soon as labor begins.

Many obstetricians are in the habit of giving their patients printed instructions during pregnancy. The following have been of use to the author:

DIRECTIONS FOR PATIENTS DURING PREGNANCY.

(*a*) Take as much outdoor exercise as possible, but guard against overtiring yourself.
(*b*) See that the bowels are moved daily.
(*c*) On the first day of each month send me an eight-ounce bottle of mixed (night and morning) urine; and for the two months preceding the expected date of confinement, send it on the first and fifteenth days of the month.
(*d*) From the sixth month onward, bathe the nipples night and morning with the following solution: four ounces of alcohol and water, half ounce borax.
(*e*) Six weeks before the expected date of confinement buy a "Confinement Outfit" from Hynson, Westcott & Co., Charles and Franklin streets, Baltimore. In this is included everything which will be needed by the nurse and myself except baby's clothes. At the same time procure a piece of rubber sheeting one by two yards, a bed pan, three small round agate basins, a two-quart fountain syringe, fifteen yards of gauze or cheese cloth and two packages of absorbent cotton.
(*f*) Send for nurse as soon as labor pains commence, and let her use her judgment in sending for me, unless some emergency arises.
(*g*) Notify me at once if any of the following symptoms be observed at any time during pregnancy:
   1. Scanty urine.
   2. Persistent headache.
   3. Disturbance of vision.
   4. Swelling of feet or face.
   5. Loss of blood.
   6. Persistent constipation.
   7. And also when you feel that anything is not as it should be.
(*h*) I shall call to see you about six weeks before the expected date of confinement, to measure your pelvis and give you any desired advice.
(*i*) Send your nurse to see me as soon after she is engaged as may be convenient.

And these to the obstetrical nurse.

DIRECTIONS FOR OBSTETRICAL NURSE.

Preparations before Labor.

(*a*) "Confinement Outfit," and the other articles called for in "Directions for Patients," which include everything you or I shall need except baby-clothes.
(*b*) Prepare a sufficient number of sterile bed and vulval pads.
(*c*) A week before the expected date of confinement prepare four packages for me, two containing six towels or diapers each; one containing a sheet, and another containing a pound of cotton. These dressings should be pinned on towels or old muslin, sterilized by baking one-half hour in an oven, and not opened by any one except myself.

At Time of Labor.

(*a*) As soon as labor pains begin, notify me by telephone or message, state in the message exactly the state of affairs that exists, do not say "come at once," unless in case of emergency; in this way, if it is not necessary for me to see the patient at once, I can make my plans accordingly.
(*b*) At commencement of labor prepare two large pitchers full of boiled water, covering them with a clean towel.
(*c*) When labor has definitely set in, give the patient a warm bath and a soap suds enema.
(*d*) Make up the bed on the *right* side.
(*e*) Procure a piece of oilcloth or an old rug to protect the carpet.
(*f*) *Don't give vaginal douches of any kind.*
(*g*) *Don't examine patient vaginally under any circumstances.*
(*h*) Prepare the patient for vaginal examination by placing her upon a Kelly rubber pad, and then wash the genitalia thoroughly with soap and hot water, using cotton pledgets instead of a wash cloth. Wash from above downward (toward the anus). Cut the pubic hairs if necessary, then bathe the vulva with a 1 to 1,000 bichloride solution, afterward covering it with a folded towel soaked in the same solution.
(*i*) Before vaginal examination prepare patient so that I can see what I am doing without unnecessary exposure. This is best done by drawing up the gown and covering the legs and thighs with a loose sheet. When the birth of the child appears imminent, roll the night gown up above the patient's hips and pin in position, then put on the obstetrical leggings.

After Labor.

(*a*) As soon as labor is over, cleanse the genitalia with cotton pledgets and water, and then bathe with bichloride solution, after which apply a sterilized vulval pad and place the patient upon a sterilized bed pad.
(*b*) Don't use an abdominal binder until after the tenth day, unless otherwise directed.
(*c*) Change vulval pads as often as necessary, washing the genitalia each time with a 1 to 4,000 bichloride solution.

THE MANAGEMENT OF LABOR.—(*a*) *The Obstetric Call* should be answered at once no matter what the engagements or obligations of the physician may be. If at the theatre or some social function at a time when a case of labor is expected he should always leave directions how he can be found, and should respond to them at once. At times this may be very inconvenient, but nevertheless the practice should be followed rigidly. If he is in attendance upon another case of labor, it is perfectly permissible for him to leave that case if her condition be not such as to demand his actual presence, and after having seen the second case he can return to the first. In this way it is easily possible to manage two cases at the same time, but there should always be a substitute within reach. According to the opinion of the author, the patient first beginning labor has the right of priority, and if the substitute has to be called, he should be sent only to the second case. Others believe, and it is doubtful which is the better position to maintain, that the duties of the obstetrician are with the woman who is more seriously ill, and the substitute should be left with the easier case.

(*b*) *The Obstetric Armamentarium.* The average obstetrical valise which is sold by instrument makers is entirely too small to carry sufficient material for properly managing a case of labor. It little matters as to the shape of such a receptacle, so long as it is large enough. Valises have been devised by Edgar of New York, Williams of Baltimore, and the author, which present distinct advantages over the little hand satchel that has been so long in use. The valises of Edgar and the author are practically identical in their general plan of construction which is as follows: Two porcelain trays, one deep and one shallow, are so constructed that the deep one fits into the shallow. The space within the trays is used for packing bottles, dressings, and instruments, and the entire nest of trays is covered by a leather carrying case. That of the author is essentially the same as the one just described, but, being made for the permanganate-oxalic technique, it contains two smaller basins which fit into the large one. The

method of using either of these valises is obvious. When the operator arrives at a case he unpacks his various trays and uses them to make his antiseptic solutions in, and for sterilizing his hands. The trays are so large that they permit the entire forearm to be soaked, and can be used also for boiling instruments, or bathing an asphyxiated child. Where suitable basins are not available such an armamentarium is indispensable, but if the patient has previously been instructed to have the necessary basins, the outfit of Williams is probably the best. This consists of a small hand trunk with the proper compartments and straps for carrying bottles. Its most important adjunct is a small metal box of sufficient size to hold comfortably a pair of obstetric forceps. When the valise is packed this box contains all the instruments, and if necessity arises to use them the box is placed directly upon the stove and the contents will soon come to a boil. In the unused space can be packed the dressings, etc.

The obstetric valise should contain the following articles. Drugs: oxalic acid, permanganate of potash, bichloride tablets, ergotole, chloroform, hypodermic syringe and tablets. Instruments: a pair of obstetric forceps (best, Tarnier's axis traction), Braun's cranioclast, Smelley scissors, pelvimeter, perineal instruments consisting of a needle holder, dissecting forceps, two pair of artery clamps, a pair of scissors, needles, and silkworm gut ligatures, a nail brush. Dressings: wrapped in separate bundles and sterilized, vulval pads, gauze sponges, two or three roller bandages, to pack the uterus in case of hemorrhage, half a dozen sterilized towels, gauze wipes for eyes and mouth, and bobbin for cord ligature.

(*c*) *Obstetric Antisepsis.*—This is the most important subject of the present paper, and had best be considered under three headings: namely, the nurse, the physician, and the patient.

1. *The Nurse.* At the present time the profession is much better supplied with obstetric nurses than twenty years ago, and almost every patient can have at the time of her confinement one to nurse her who has had a regular training in some well-appointed lying-in hospital. She should be a woman who has been well trained in the principles of antisepsis and asepsis, should not have recently been in contact with an infectious case of any kind, and should possess the natural discretion which will render her capable of getting along with the members of her patient's family and the servants. Most trained nurses have been taught how to make the vaginal examination of a woman in labor at the hospital from which they receive their training. In private practice, however, it is well to allow them to do this only under exceptional circumstances. If the physician in charge is going to take the entire responsibility of the case, it is far better that he, and only he, subject the patient to the risk of infection. The passage of the catheter is another danger that should be entrusted to the nurse only after the physician has thoroughly investigated her technique in such a procedure.

When one is dealing with an untrained nurse, it is best to allow her no more technical privileges than if she were a member of the laity. In the experience of the author such women know nothing of antiseptic technique, and the faith that a few of them have in a little bichloride solution makes them excessively dangerous in the lying-in room. These women should never be allowed to examine vaginally and never under any circumstances to pass the catheter.

2. *The Physician.* The personal and surgical cleanliness of the obstetrician is by far the most important factor of technique. From the personal side he should bear in mind that he comes in contact with sensitive women at a time when any little caprices they may have are exaggerated. His clothing should be neat and his linen always clean. His technical cleanliness is, of course, important in that it diminishes the risk of infection. The physician in general practice should use the greatest care thoroughly to disinfect his hands and his clothes after having them in contact with a septic case of any kind. If he does not feel certain that he has gone through the proper precautions, it is far better that he should send a substitute to the obstetrical case. The general care of his hands would require special attention and they should as far as possible be kept free from small wounds, abrasions and scratches, for it is in these situations that germs may thrive, to be transmitted to his patient during a vaginal examination. Haegler (Basel, 1900, ref. *Centralblatt für Chirurgie*, 1900, No. 46) and Bloodgood (*Progressive Medicine*, 1901, December) both agree in this danger of slight wounds on the hand. The latter claims that a prolific source of infection is the caking of blood around the interstices of a finger nail, and that since he has worn rubber gloves, his hands have been in a better condition. Williams ("Jewett's Obstetrics," second edition) calls attention to the danger afforded by infected wounds, bone felons, or a pustulous eczema on the hands of the obstetrician. Contact with septic material of any kind, not only in other patients, but upon the person of the physician himself, should be strictly avoided. In this connection it is only necessary to recall the case of Dr. Rutter, of Philadelphia (Williams, *loc. cit.*), who was followed wherever he went by an epidemic of puerperal fever, while his brother practitioners were practically free from it. It appeared later that the source of infection was a purulent ozæna from which he infected his hand every time he blew his nose. It is now known beyond any question of doubt that infection of all kinds is produced by contact; hence the old theory that sewer gas plays an important part in its production can be abandoned. Garrigues ("American Text-book of Obstetrics," first edition) in a recent article advocates this theory and attributes an epidemic occurring in the New York Maternity Hospital to guano which had been sprinkled over the ground, and a second one in the New York Infant Asylum to the presence of a dead rat in the cellar. We cannot agree with him, however, in believing the possibility of air infection.

The actual disinfection of the hands was originated in 1847 by Semmelweiss (Wien und Leipzig, 1861), who was struck with the frightfully high mortality of women delivered in lying-in hospitals. Thinking this might be due to the contamination of the hands of the assistants by handling pathological material, he compelled them to bathe their hands in a solution of chloride of lime, and was rewarded in seeing the mortality immediately drop. It was not, however, until Lister had introduced his antiseptic method into surgery, until Stadtfeldt, of Copenhagen (cited by Williams, *loc. cit.*), had advocated the use of bichloride of mercury in obstetrics, and until Pasteur (*loc. cit.*) had found streptococci in the tissues of women dead of puerperal fever, that obstetricians in general began to disinfect their hands.

The methods of disinfection at present in use are as follows: That of Fürbringer, by which it is claimed the hands can be made sterile more rapidly than by any other method. His method, as quoted by Jewett, is as follows:

(1) Clean the nails dry.

(2) Scrub the hands and forearms for not less than three minutes with a hand brush with soap and water as hot as it can be borne; especial care must be taken in brushing the nails and finger tips, and the water should be changed two or three times.

(3) Scrub well with alcohol (not below eighty per cent.) and, before it evaporates,

(4) Immerse for three minutes in a hot solution of mercuric iodide or chloride (1 to 2,000 to 1 to 500) or in a three-per-cent. solution of carbolic acid.

A fallacy has been discovered in this method by Menge and Krönig, who show that the organisms are not destroyed but simply made to adhere more closely to the hands, and Senger (*Centralblatt für Chirurgie*, 1899, No. 27) has proven that alcohol and carbolic acid form an inert chemical combination. Senger has found the following method of value, which is based upon not only the actual germicidal properties of the mixture, but also upon its chemical combination, the importance of which was advocated by Krönig and Paul (*Zeitschrift für Hygiene und Infectionskrankheiten*, Bd. 25, 1897). It is—

(1) After thoroughly scrubbing the hands as heretofore described they are immersed for two minutes in a solution of hydrochloric acid of from two- to five-per-cent. strength.

(2) This is followed by immersion in one-half- to two-per-cent. solution of permanganate of potash for one minute.

(3) A solution of sulphurous acid is used to remove the discoloration.

The virulence of this combination is due to nascent chlorine, nascent oxygen, and nascent sulphuric acid, which, the authors (Krönig and Paul) claim, are much more effective in this state. Bloodgood (*loc. cit.*) is unable to state whether this combination is better than permanganate of potash and oxalic acid, and says that his results with the latter method have been such that a change does not seem necessary. In this the author entirely agrees with him. But the method of Krönig and Paul is based on such excellent laboratory work that it cannot be overlooked.

The permanganate of potash and oxalic acid method, which was originated by Halsted and later described by Kelly (*American Journal of Obstetrics*, 1891, xxiv., No. 12) (it has been wrongly referred to as that of Welch [Jewett, "American Text-book of Obstetrics," first edition]), is the one used extensively in this country and the one with which the author has had most excellent results both in hospital and in private practice. It is as follows:

(1) The hands are thoroughly scrubbed with hot water and green soap for from three to five minutes, the water being changed several times.

(2) The hands are immersed in a warm solution of potassium permanganate until they attain a mahogany brown color.

(3) They are then decolorized in a hot saturated solution of oxalic acid.

(4) Soak the hands and forearms for at least two minutes in a 1 to 1,000 solution of bichloride.

All observers agree that the most important step in any of the above methods is the mechanical scrubbing, but most of them agree with Haegler (*loc. cit.*) in the opinion that chemical disinfection cannot be dispensed with.

Rubber Gloves. According to Bloodgood (*Progressive Medicine*, December, 1899), rubber gloves were first used by Halsted in 1889. If properly employed they practically solve the question of hand disinfection for the reason that they can be absolutely sterilized by boiling. Their use in general surgery has been shown by Bloodgood to diminish the frequency of wound suppuration markedly. Up to the present time gloves have not been used extensively in obstetrics. Williams advised them, but claims that they interfere considerably with the sense of touch. Moran, of Washington (*American Journal of Obstetrics*, February, 1902), has made a comparative study of the results obtained by the use and non-use of rubber gloves in the management of obstetric cases. His results undoubtedly show a slight decrease in the morbidity, as is seen by the following figures: from July 1st, 1899, to September 30th, 1900—318 cases were treated of which 180 were examined during or after labor, and 138 were not examined. Of those that were examined 40 (22 per cent.) had a rise of temperature of above 100° F., and of those not examined 26 (19 per cent.) one above normal. In this series of cases gloves were not used. From October 1st, 1900, to May 30th, 1901, 237 cases were treated with rubber gloves. Of those examined, of which there were 197 cases, 43 (or 20.7 per cent.) had a rise of temperature, and of those not examined, 40, 7 (or 17.5 per cent.) had this rise. If these results are compared it is seen that without gloves the morbidity was 22 per cent. and 19 per cent. for the examined and not examined cases respectively, while with gloves this morbidity was 20.7 per cent. and 17.5 per cent. Although these figures show only two or three per cent. morbidity in favor of gloves, yet this author shows clearly that this small difference is due partly to the fact that many general diseases increase the morbidity. His results as to actual infections definitely prove that this complication is decidedly less frequent when gloves are used and even less so when the patients are not examined. In the opinion of the author it is exceedingly difficult, if not impossible, to do some of the major obstetric operations, namely, high forceps and version, if gloves be worn. It is his practice to wear gloves only in dirty cases, thus keeping his hands always clean.

To summarize the question of hand disinfection, it is well to note that except by the careful use of rubber gloves which have recently been boiled, it is impossible to sterilize the hands from a bacteriological standpoint. For practical purposes, however, the method of Krönig and Paul, or that of Halsted, will be found sufficient. And if it be remembered that, as the hand cannot be absolutely sterilized, any unnecessary manipulation or examination subjects the patient to a certain risk of infection, the operator, by avoiding this, will do all that is in his power.

3. *The Patient.* The question of proper antisepsis on the part of the patient is just as important as that of the physician, and the entire field of operation, namely, the vulva and the inner surface of the thigh, should undergo a rigid disinfection. It should be remembered, however, that this disinfection can never be as complete as that of the surgeon's hands; these parts, therefore, should not be touched during the operation with a disinfected hand any more than is absolutely necessary. In hospital practice the vulva can and should be shaved, for in the average hospital patient it is almost impossible to render the pubic hair sterile. It would be best if this same technique could be used in private practice, but to this the average woman will not submit. Warren (*American Journal of Obstetrics*, January, 1902) says that the chief objection to it is the discomfort that follows when the hair begins to grow out again, nor does Bowen (*American Journal of Obstetrics*, December, 1901) advise it, but both of these operators think it best that the pubic hair should be clipped short with scissors. The necessity of thoroughly cleansing the vulva has been emphasized by the excellent laboratory work of Williams (*American Journal of Obstetrics*, 1898). He was struck with the discrepancy that existed in the various opinions as to the bacterial flora of the vaginal secretion, and, thinking that the differences in results were due to differences in technique in the methods of obtaining the secretion, he made a comparative study in the several methods as follows: In a series of cases he made cultures from the vaginal secretion (*a*) by means of Menge's tube, (*b*) using a glass speculum and obtaining the secretion directly by means of a platinum loop, and (*c*) taking cultures directly from the inner surface of the labia and vestibule. From each case were the above three cultures made, and the results showed that by means of the Menge tube no pathogenic organisms were found in the secretion, while when the speculum was used such organisms were found quite frequently, and they corresponded identically to the organisms found in the cultures made from the external genitalia, showing conclusively that even by the careful introduction of the cylindrical glass speculum it was almost impossible to avoid introducing germs from without.

As regards the actual method of disinfection little need be said in addition to what has gone before. After clipping the pubic hair short the vulva and inner surface of the thigh are thoroughly washed with warm water and green soap. This is to be followed by copious irrigation with bichloride solution, and then a pledget of gauze wet with the same solution is to be allowed to lie over the vulva until the examination is made.

The ante-partum douche is at present little used, and it seems superfluous to say much about it. However, a few words in regard to the rationale of its abandonment will not be out of place. Up to 1892 there were two beliefs as to the bacterial flora of the vaginal secretion. Certain authorities, on the one hand, claimed that the secretion was invariably free from pathogenic micro-organisms, and, according to them, the ante-partum douche was superfluous. On the other hand, another school of observers claimed that pathogenic bacteria were present in a certain percentage (from 4 to 27 per cent.) in the vaginal

secretion of pregnant women, and, according to these authorities, douching of the vagina preparatory to labor was necessary. In 1892 the question was apparently settled by the work of Döderlein ("Das Scheidensekret," Leipzig, 1892) who divided vaginal secretion into two classes: on the one hand, a normal secretion which presented certain characteristics and contained only the bacillus vaginalis and yeast fungus, and, on the other, an abnormal secretion which presented certain differential characteristics, and which frequently contained pathogenic organisms. In the former class of cases this observer argued that douches were not necessary, while in the latter they were. In 1893 Williams (*American Journal of the Medical Sciences*, July, 1893) confirmed Döderlein's work on a small scale, and for the next few years it held good. In 1897 Krönig ("Bacteriologie des weiblichen Genitalkanales," Menge und Krönig, Leipzig, 1897) surprised vaginal bacteriologists by the statement that he had examined the vaginal secretion of 167 pregnant women, and that in none of them was he able to demonstrate typical streptococci or any other pathogenic micro-organisms with the exception of the gonococcus. He therefore concluded that the vaginal secretion should be considered aseptic, and that ante-partum douches were not indicated. Furthermore, he proved that the vaginal secretion was itself bactericidal, for chromogenic and mildly pathogenic organisms when introduced into the healthy vagina could not be recovered in cultures taken a few hours later, and that if the vagina previous to the introduction of these organisms had been douched or scrubbed the bactericidal power of its secretion was decidedly lessened. He was thus justified in concluding that the ante-partum douche was not only unnecessary but also injurious. Krönig's work has been confirmed by Williams (*loc. cit.*), who has also shown that the former discrepancy as to the bacterial flora of the vagina was due to differences in technique (*loc. cit.*). From the practical standpoint Bretschneider (*Archiv für Gynäkologie*, 1901) reports statistics from the Leipsic Clinic in which, of 2,280 cases, every alternate one was douched. The puerperium was febrile in 45.18 per cent. of the cases douched, and in 36.78 per cent. when the douche was not employed.

It is thus seen that we are justified in condemning the use of the ante-partum douche and in believing that, with the exception of those affected with gonorrhœa, auto-infection is impossible. Just so long as the obstetrician works with this point in mind will his technique be good, but so soon as he uses auto-infection as a peg upon which to hang faults in his technique will his patient suffer.

It may likewise be said that the post-partum douche in normal cases is productive of more harm than good. The natural cleansing that the genital tract gets during the birth—first the douche, from above downward, of liquor amnii, followed by the tightly fitting body of the child and more fluid, and finally by the placenta—is far superior to any artificial means such as a douche. This stage of the labor, then, had far better be left entirely to nature.

(*d*) *The Technical Management of Labor.*—This subject will be considered under the three clinical stages of labor.

1. *During the First Stage.* When the nurse is called to a case of labor her first duty should be to dispel any possible fear on the part of the patient by her general demeanor and remarks. It is supposed that the necessary preparations, dressings, and so forth have been made some time before. Having ascertained by questions as to the duration and character of the pains, the amount and character of the vaginal discharge, she should give the patient an enema of soap suds and warm water. This emptying of the lower bowel is a very important procedure, and should never be omitted. The patient should then be directed to take a full bath, paying particular attention to the thorough cleansing of the lower abdomen, vulva, and thighs. Her hair should be braided, so that it will become as little tangled as possible when she is lying in bed. Most nurses arrange the hair in two braids on either side of the head. She should be dressed in a clean night gown and put to bed. She is now ready to see the physician, and, until he makes the vaginal examination, no further disinfection is necessary.

The first duty of the physician on entering the room is to discover whether or not his patient is in labor. Many ludicrous mistakes have been made which could have been avoided by bearing this point in mind. One of the first cases witnessed by the author as a student was watched throughout an entire night, only to find—when, in the morning, he sent for the demonstrator of obstetrics of the medical college to apply forceps—that the patient was not in labor. Many of us can recall similar instances. The three signs indicating that labor has actually begun, according to Hirst (*loc. cit.*), are as follows: (*a*) Recurrent pains of characteristic duration, situation, and nature; (*b*) the escape of a small quantity of blood-tinged mucus from the vagina, and (*c*) the dilatation of the os. (*b*) may be absent in the early stages of labor, and (*c*) is found only on vaginal examination, to be described later. As a rule the uterine pains will suffice for making the diagnosis, and the physician should then proceed with his examination of the patient. If she is seen for the first time, the history and the examination should be as complete and thorough as heretofore described. If, however, this has been done some weeks previously, all that is necessary will be the palpation and auscultation of the abdomen, by which he ascertains the position and presentation and condition of the child.

Vaginal examination during labor should be made only with the strictest antiseptic precautions, and after the patient and hands of the physician have been prepared in the manner heretofore described. During the first stage of labor the points to ascertain by vaginal examination are the condition of the membranes and the amount of dilatation of the os. The presenting part can be felt, but it is almost impossible at this time to obtain definite information as to its position.

Later in labor, when the cervix is completely dilated, and the presenting part has descended into the pelvis to a level with the ischial spines, the diagnosis of the presentation and position of the child can be made by noting the relation between certain anatomical structures upon the presenting part and the mother's pelvis. These structures are, in the case of occipito-iliac presentations, the large and small fontanels, and the sagittal suture; in mento-iliac, the bridge of the nose, the mouth and chin; and in sacro-iliac, the genitals, gluteal furrow, and the tip of the coccyx. It can be easily seen what relative position these structures will occupy in any of the classical presentations.

In making the diagnosis of presentation and position by vaginal examination, it is well to have a definite method of procedure, analogous to the one considered when abdominal palpation was discussed. The most practical is a method advised by Farabœuf and Varnier ("Introduction à l'Étude clinique et à la pratique des Accouchements," Paris, 1891) which consists of three separate manœuvres, as follows:

The disinfected finger is introduced into the vagina until it comes in contact with the presenting part. By this first manœuvre, which is simply feeling the part of the child in the pelvis, the diagnosis of the presentation is made, be it occiput, breech, or face. In the second manœuvre, the examining finger is made to pass from anterior to posterior over the presenting part in the middle line. In its journey it will cross either the sagittal suture, the bridge of the nose, or the gluteal furrow, and, according to the direction of either of these structures, will the operator know the direction of the antero-posterior diameter of the presenting part; in other words, its orientation. By the third manœuvre the presenting point is located and the diagnosis thereby clinched. This is accomplished as follows: The tips of the fingers again are brought to the anterior aspect of the presenting part, and are made to sweep over it first on one side and then on the other in a semicircle. In this journey the presenting point, be it small fontanel, point of the chin, or tip of sacrum, will be found, and according to the quadrant of the pelvis it occupies the diagnosis is made.

To illustrate: The operator on introducing his finger comes in contact with the hard globe of the head crossed by its sutures and perforated by its fontanels. Thus he knows he is dealing with an occipito-iliac presentation. By the second manœuvre he locates the sagittal suture and notes that it runs from left anterior to right posterior; thus his diagnosis will be: left occipito-iliac anterior or right occipito-iliac posterior, according as the small fontanel is felt at the anterior or posterior end of the sagittal suture. By sweeping the tips of his fingers around the presenting part, first on one side and then on the other, as indicated in the third manœuvre, he finds the small fontanel at the anterior end of the sagittal suture, or in the left anterior pelvic quadrant. From this he will be justified in making the diagnosis of the presentation as left occipito-iliac anterior.

In transverse presentations this rule cannot be followed. But if the operator remembers that the axillary cavity is closed in the direction of the child's head, open in the direction of its feet, bounded anteriorly by the soft pectoralis major muscle, and posteriorly by the hard border of the scapula, a mental process of reconstruction will give him a correct idea of the position occupied by the child.

In operative cases, particularly where the use of forceps is anticipated, accurate diagnosis of presentation and position is of absolute importance, and as the formation of the caput succedaneum often makes it impossible for the operator to feel the suture and fontanels, a method other than that which has been described above must be resorted to. With the patient under complete anæsthesia, it is always possible to introduce the entire hand into the vagina. It is passed along the side of the head until the ear is reached. As the free border of the ear is directed posteriorly, its position will give the operator the desired information.

After he has made the examination, the physician will be asked for his opinion as to the probable duration of the labor. Hirst says on this point, it is well to be "guarded and delphic," and he is accustomed to make the somewhat ambiguous statement "that the duration of labor will depend upon the strength and frequency of the pains." If the operator bears in mind the average duration of labor in primipara and multipara as being seventeen and nine hours, respectively, from the first onset of pains, he will be greatly helped.

The duties of the physician during the first stage of labor—further than assuming an attitude of watchful expectancy—are practically nil. If his patient be a primipara with infrequent pains and slow dilatation, it is best that he should not remain in the house, but should pay frequent visits, leaving word in the interval where he can be called. If, on the other hand, his patient has had children before and gives a history of rapid labors he should be with her during the entire process. In both instances the number of vaginal examinations should be restricted, as with each one the risk of infection is increased. It is perfectly possible, if the question of time is not of importance to the obstetrician, to manage many cases entirely by external manipulation. Leopold and Spörling (*Archiv für Gynäkologie*, xlv.) and Leopold and Orb (*Archiv für Gynäkologie*, xlviii.) state that it is possible, from their own experience, to deliver at least ninety per cent. of all cases by means of external manipulation alone. Their errors in diagnosis in the first thousand cases delivered were 6.5 per cent., while in the last thousand they were only 1.77 per cent., and Moran (*loc. cit.*) states that the morbidity of cases examined is double that of cases not examined. If the obstetrician is in general practice, however, and cannot remain with his patient from the first visit, vaginal examination is absolutely necessary, for it is by this means alone that he can tell the amount and rapidity of dilatation. It is the habit of the author to examine primiparous women rarely more than twice during the first stage, and multiparous never oftener than once, and frequently not at all.

2. *During the Second Stage.* The most important point for the physician to observe during this stage of labor is the maintenance of a rational technique, and by a "rational" technique is meant the handling with disinfected hands only such articles as are known to be sterile. Nothing has been said heretofore concerning the sterilization of bed clothes, night gowns, and so forth, it being thought far better to have these articles simply freshly laundered, for if such articles be sterilized when first used, it is a matter only of a few minutes before they become completely contaminated, and it is preferable that they be considered non-sterile from the outset than to consider them so through the entire case, and thereby contaminate not only hands and instruments, but other dressings.

When, by the rupture of the membrane or the onset of expulsive pains, the obstetrician knows that his patient has entered the second stage, she should be made to lie on her back and sterile leggings should be drawn over the legs and thighs; and the gown is rolled up so as to be well out of the way of discharges from the vagina. With each pain either he or the nurse should watch the perineum, and when it is seen to bulge, he may prepare his hands for the actual delivery, and while he is doing so the nurse prepares the patient. Having disinfected his hands, he sits on one side of the bed and surrounds the vulva with sterilized towels. To do this four towels are necessary: one lying transversely, directly under the patient's buttocks, one lying diagonally under each thigh, and one across the abdomen, exposing to plain sight the vaginal orifice. In this way the vulva and surrounding towels form a sterile field, and it should be remembered that this is the only portion of the patient or bed that is in that condition.

On a table or chair by the side of the bed and within easy reach of the operator's hand is placed a sterile towel, and upon it the following articles: scissors and ligatures for the cord, sterile gauze sponges, a basin with bichloride solution.

While the head is distending the vulva, the operator has two duties: first, to prevent contamination of the field of operation by discharge from the rectum, and second, to prevent, if possible, laceration of the perineum. The first duty is fulfilled by wiping the discharge from the rectum downward with a sponge soaked in bichloride, which sponge is, of course, at once to be thrown away. The prevention of perineal laceration, however, is a much more difficult matter and will not be successful in a number of cases. Many methods have been devised, some good, others bad. Any method that depends upon a rectal manipulation is bad for the reason that it contaminates the hand which may later have to be introduced into the uterus. If the operator bears in mind that the usual causes of the laceration are, first, too rapid expulsion of the presenting part, and second, some abnormality in the mechanism of labor, any method which has as its object the avoidance of these causes will be a good one. Too rapid expulsion of the presenting part can be controlled by a carefully administered anæsthetic, and the normal mechanism of labor can be assisted by pressing through the perineum upon the fœtal head so that the neck is forced upward against the symphysis pubis and extension of the head thereby assisted. A method which has been as successful as any with the author is as follows: When the head distends the vulva, the operator facing his patient's feet places the first two fingers of both hands upon the perineum, so that the finger tips of one hand are in apposition with those of the other; by this means pressure is made upward and forward, and the head when delivered slips, as it were, between the fingers and thumbs of both of the operator's hands. An ingenious device has been recently recommended by George H. Noble (*American Journal of Obstetrics*, February, 1902), by which the perineum is supported by means of three adhesive straps one and a half inches wide and eighteen to twenty-four inches long; when the head distends the vulva the end of one strap is applied in the vulvo-femoral crease while its other end runs diagonally downward across the opposite buttocks; a second one is applied in the same way on the other side of the body, and the third

running directly transversely a few millimetres below the posterior commissure. Noble has used this method in six forceps deliveries in which laceration seemed imminent, "with perfect satisfaction." The author has no experience with this method. A possible objection is the difficulty of obtaining sterile adhesive plaster.

The head being delivered, it undergoes its movement of external rotation. The operator now turns so that he faces his patient's head and grasps the fœtal head with both hands by chin and occiput. Downward pressure will cause the anterior shoulder to slip under the symphysis and elevation of the head will cause the posterior one to glide over the perineum. The rest of the child's body usually follows without difficulty. Difficulty in delivering the shoulder sometimes occurs, and to relieve this Bonnaire (cited by Norris, *Progressive Medicine*, September, 1901) suggests the division of one of both clavicles by means of sharp scissors. The operation has apparently not been performed upon a living child, though Bonnaire thinks it possible, as in none of his experimental operations were the subclavian vessels or nerves injured. Happily, arrest of the shoulders is exceedingly rare.

Throughout the entire second stage the condition of the fœtal heart sounds should be carefully noted at short intervals.

Anæsthesia in Obstetrics.—All obstetricians agree that a certain amount of anæsthesia properly administered is of greatest assistance in the majority of obstetric cases, and most individuals in private practice use an anæsthetic as a matter of routine. The time for administration of the anæsthetic is in the second stage of labor, and as a rule its administration should be put off as long as possible. It should never be given except in operative cases before the cervix is completely dilated, nor should the attempt be made to produce narcosis, but simply anæsthesia. If this be done it is perfectly possible for the patient to be partially conscious throughout the entire process, but at the completion of labor to have no definite recollection of it. The choice of the anæsthetic should be governed by several factors: in the first place, the general condition of the patient, and in the second, the individual preference of the operator. That ether and chloroform both have their dangers is clear on perusing the excellent review of recent literature by Bloodgood in *Progressive Medicine* for December, 1901. The general conclusions to which he comes are that on the whole ether is a safer anæsthetic, as experiments on animals have proven that it does not produce the same amount of fatty degeneration of the internal organs as chloroform. On the other hand, late deaths from lung complications seem to be commoner after ether. That chloroform is a proverbially safe anæsthetic in obstetrics has long been known, yet too much confidence should not be put in this statement. Lusk cites a case ("Text-book of Obstetrics," fourth edition) in which a patient was almost lost during the performance of version, and the author has seen several cases in which alarming symptoms due to the anæsthetic have developed. In patients who are otherwise healthy, it is the opinion of the author that chloroform should be the anæsthetic of choice, as it is much more easily administered and is not followed by the disagreeable after-effects of ether. Although some claim that with ether it is possible to produce the condition known as "obstetric anæsthesia," in which the patient though conscious is insensible to pain, it is probable that this condition is not produced to the same extent nor with the same ease as with chloroform. In conditions of disease of the lungs and kidneys chloroform should still be used; in heart lesions, where compensation is good, and there is no œdema of the lung, ether will probably be the safer anæsthetic; but if the lesion be accompanied by a lost compensation and consequent involvement of the lung, the preference had better be for chloroform. If for any reason it is anticipated that the anæsthesia will be prolonged, ether will give the patient a better chance.

The effect of an anæsthetic upon the contraction of the uterus has recently been studied by Westermark (*Archiv für Gynäkologie*, 1900) who, after an elaborate series of experiments, concludes that complete narcosis by chloroform diminishes the frequency of uterine contractions, but exercises no influence upon the intra-uterine pressure during pain; it greatly diminishes, however, the pains occasioned by the contraction. Norris (*Progressive Medicine*, September, 1901) concludes from it that the use of chloroform in obstetrics should be limited to those cases in which the suffering is intense and the control of the patient becomes so necessary that it seems best to risk some prolongation of the labor in order to control her suffering. The above statement apparently refers to complete narcosis, and for that condition it is probably correct. Excellent results, however, can be obtained if partial or "obstetric anæsthesia" be used, as it appears that by this means the duration of labor is not prolonged. In the practical experience of the author it is his habit to postpone the administration of the anæsthetic as long as possible. When it appears that the patient is suffering more than she can bear, an Esmarch inhaler is held over her face at the onset of each pain, and a few drops of chloroform are applied to it. She is instructed to breathe deeply, and a few drops of the drug are applied with each inspiration. It is not uncommon to notice that the first few pains after the commencement of the anæsthetic are less in intensity and frequency, but that their former regularity is soon restored. The patient should be told that she will not be completely unconscious, but that the anæsthetic will lessen the severity of the pains, and it will be found that if two or three full inspirations of the anæsthetic are allowed at the close of each pain she will have little or no recollection of the suffering. In the interval between the pains the anæsthetic is discontinued only to be given again when the patient says a pain is beginning.

In the latter part of the second stage, when the head is about to emerge from the vulva and the pains are practically continuous, the anæsthetic should be pushed, not, however, to complete narcosis, but until the patient fails to answer questions. Under these conditions the abdominal and uterine muscles act with perfect regularity, and at the close of the labor the patient has no recollection of the actual birth of the child.

Medullary Narcosis in Obstetrics.—Credit must be given to Corning, of New York, a neurologist, for first having produced anæsthesia of the lower half of the body by the injection of cocaine into the spinal cord. His work, however, created little comment, and it was not until a few years ago that Bier's work on this subject called the attention of surgeons in general to its possibilities. It should be stated, however, in justice to Bier, that he knew nothing of Corning's work at the time of the publication of his article. In a collective review by Fr. Hahn (*Centralblatt für die Grenzgebiete der Medicin und Chirurgie*, vol. iv., 1901) the obstetrical aspect of the method is thoroughly considered. He says, a further field for spinal cocainization appears to lie in the domain of obstetrics, to reduce the pains of labor. Kreis in Basel (*Centralblatt für Gynäkologie*, 1900, No. 28) was probably the first one to make this test. At the suggestion of Professor Bumm he cocainized the spinal cord in six cases of labor. After the injection of 1 cgm. of cocaine there was analgesia up to the navel while at the same time the mobility of the uterus was not perceptibly impaired. The pains came with the same frequency and intensity as before cocainization, and the sense of pain was so completely absent that the uterine contraction was felt only as tension in the lower abdomen. The passage of the head through the vagina and vulva, the introduction of forceps and perineal sutures were all painless. The only defect was the absence of the spontaneous reflex action of the abdominal muscles, as the patient had no desire to bear down unless urged to do so. The third stage was also perfectly normal and there were no complications. Kreis regards cocaine contraindicated only when active co-operation of the abdominal muscles cannot be dispensed with, also in frightened and excited women. In simple operative cases, according to this observer, it may replace chloroform narcosis, for the particular rea-

son that it can be administered without any assistance. Marx (*Medical News*, August 25th, 1900) reports over forty cases, all with good results. The children were all born alive and well even in serious complicated cases. The period of convalescence is smoother than after anæsthesia by the old method. This author never noted any disturbance of the normal action of the uterine muscles, nor was there any inclination to hemorrhage. In one case he succeeded, by repeated injections, in keeping his patient free from pain during eight hours of labor. He also advises this form of anæsthesia for examination of the pelvis. Doléris (*Bul. de l'Acad. de Méd.*, July 17th, 1900) goes still further, and according to him cocaine increases the duration, frequency, and intensity of uterine contraction, thus making the labor more rapid, and putting the uterine muscle in a condition which he designates as pseudo-tetanic. At the same time it acts as a hæmostatic without, however, injuring the fœtus, interfering with the course of delivery, or impeding operative intervention. He was able to observe this condition of the muscle directly in a case in which Cæsarean section was done. Working along these lines this observer tried cocaine to bring on artificial abortion, and in two cases, by the intraspinal injection of 1 cgm. of cocaine, he succeeded in bringing about such energetic contraction of the uterus that delivery followed from four to six hours later. Thus we have in cocaine a new method for the induction of premature labor, to say nothing of its possible use in atony of the uterus. A corollary to this observation is that spinal cocaine is contraindicated in general surgical operations upon pregnant women, as an abortion might result. Other observers express themselves emphatically in favor of this method of obstetric anæsthesia. Dupaigne (*Bul. de l'Acad. de Méd.*, August 28th, 1900) says, in properly selected cases it is simply ideal. Others may be mentioned, as Stouffs (*Centralblatt für Gynäkologie*, 1901, No. 1) and Guéniot (*Bul. de l'Acad. de Méd.*, January 22d, 1901). This latter observer suggests the following indications as a substitute for general anæsthesia in cases with severe, weak or slow, irregular pain, and in tendencies to hemorrhage. It is contraindicated, he says, in chronic heart and lung affections, and in nervous women. More sceptical as regards spinal anæsthesia is Ehrenfest (*Medical Record*, December 22d, 1900), for he says the method itself is not without danger, and the significance of the unpleasant after-effects ought not be underestimated. Voluntary abdominal action, which is so important in the period of expulsion, is absent, and it is yet a question whether the new method is not followed by derangements which are worse than the normal pains of labor. Grandin and Porak (*Bul. de l'Académie de Méd.*, January 29th, 1901) are also uncertain, the latter having had four failures in ten cases. Dumont (*Correspondenzblatt für Schweizer Aerzte*, 1900, No. 19) speaks strongly against this method which, he claims, is entirely superfluous as in no other human being are conditions more favorable for general narcosis than in the laboring woman. The effect on the child has been noted by Hawley and Taussig (*Medical Record*, January 19th, 1901) who saw five cases in which the toxic effect was marked, three of which were asphyxiated.

From the above review it will be noted that the method has its friends and its enemies. The author has had absolutely no experience with its practical application, and can only call attention to Bier's latest communication on the subject (*Archiv für klinische Chirurgie*, 1901) in which he emphasizes the fact that the method is still in its experimental stage, and to the statement made by Bloodgood (*Progressive Medicine*, December, 1901) in which he says that of 1,708 operations there are 8 deaths recorded as being due to cocaine, a much higher mortality than belongs to either chloroform or ether. This being the case the writer thinks that obstetricians are hardly yet justified in advising cocaine as a safe method of anæsthesia in private practice.

From a personal communication from Dr. Lynch, resident obstetrician at the Johns Hopkins Hospital, the author finds that he has used the method eight times and does not consider it favorably, for in three of his cases anæsthesia was not produced, and in one apparently no effect at all. The duration of the anæsthesia was only from one hour to an hour and a half, and three of his cases had to be delivered instrumentally. The effect on the mother and child was negative.

3. *During the Third Stage.* The child having been delivered, its eyes and mouth are to be at once wiped with a solution of boracic acid. After pulsation in the cord has ceased, it is to be ligated in two places, and cut between the ligatures, leaving a stump 2 or 3 cm. long attached to the umbilicus. The infant is then handed immediately to a nurse, who should wrap a sterile towel around the abdomen to prevent infection of the cord from dirty bedclothes, etc. The operator and nurse should now turn their attention to the mother. The nurse is directed to report any relaxation of the fundus of the uterus, and the operator examines the perineum for laceration and applies sutures if necessary. The method of perineal repair is considered in another section of the work. (See *Obstetric Operations.*) Suffice it to say here that in simple cases, time can be saved by applying the sutures before the placenta is delivered, after which they can be tied. The same antiseptic precautions which have been observed heretofore should be continued.

Delivery of the Placenta.—If the uterus be watched by the hand upon the abdomen for the first fifteen or twenty minutes after the labor, it will be noted to contract and relax at regular intervals. If the relaxation is not excessive and there is no hemorrhage, no anxiety need be felt. If relaxation occur, however, a contraction may be excited by general massage upon the fundus through the abdominal wall. The hand upon the uterus will notice that in from ten to thirty minutes after labor the fundus rises and occupies a position 2 or 3 cm. higher than formerly. This is an indication that the placenta has passed from the upper portion of the uterus and lies in the lower uterine segment or vagina. If now pressure be made upon the fundus of the uterus in a direction toward the hollow of the sacrum the placenta will be directly expressed through the vagina and out at the vulva. It is not uncommon to notice at this time that the attached membrane offers some resistance to extraction, which is probably due to a spasm of the cervix. This spasm, however, will probably relax in a few moments, and the membranes will then drop from the vagina. If this does not occur it is an excellent plan to twist the placenta several times so that the membranes are rolled into a cord, general traction upon which will extract them.

If it is noted that the uterus does not rise in the abdominal cavity at the expiration of one-half hour, the Credé method of delivering the placenta can be practised. By this method uterine contractions are excited by massage on the fundus through the abdominal wall, and when a contraction is felt, downward pressure in the direction mentioned above will usually deliver the placenta.

A word of caution as to the danger of manual extraction of the placenta, or, in fact, of any intravaginal or uterine manipulations during the third stage. When examinations are made in the first or second stage of labor, they are made, so to speak, inside of the amniotic cavity, which entire cavity is cast off. On the other hand, when examinations are made in the third stage the hand comes into direct contact with the abraded placental site, and hence the danger of infection is greatly increased. The manual removal of the placenta should be considered for this reason one of the most dangerous of obstetric operations, and should never be resorted to until all other measures have failed, and only then after thorough re-disinfection of the hand. Happily, a retained placenta is a great rarity.

After delivery of the placenta the condition of the fundus uteri should be watched by the hand of the nurse through the abdominal wall and any relaxation immediately reported. If at the end of one hour all is well the physician may leave the patient. *George W. Dobbin.*

LABOR, PREMATURE, INDUCTION OF. See *Obstetric Operations.*

LABOR: UNUSUAL MECHANISMS.—Under this heading are included varieties of labor due to anomalies in presentation and position of the fœtus. The mechanisms which are the result of contracted pelves, or accidents and disease, will be found described elsewhere under appropriate titles.

Vertex Presentations, Occiput Posterior.—There are two posterior positions of the occiput occurring with vertex presentations, viz., occiput right posterior and occiput left posterior. In R.O.P., which is the more common, the occipito-frontal diameter occupies the right oblique of the pelvic inlet, the occiput being near the right sacro-iliac synchondrosis; in L.O.P. the occipito-frontal lies in the left oblique with the occiput near the left sacro-iliac synchondrosis.

Diagnosis.—In posterior occipital positions the back of the child, being turned away from the antero-lateral wall of the uterus, is difficult to palpate, while the small parts are easily felt in front on the right or left side. On auscultation the fœtal heart sounds are indistinct and are heard at a point posterior to the centre of a line running from the umbilicus to one of the anterior superior spines of the ilium. When the cervix is patulous the posterior fontanel is felt with difficulty at the back of the pelvis, the sagittal suture following a direction toward the pectineal eminence of the opposite side. If flexion be not well marked the anterior fontanel is easily accessible in front and to one side.

Mechanism.—The uterine contractions often are weak in occiput posterior, probably owing to deficient reflex stimulation, and the first stage of labor may be prolonged. In normal cases descent and flexion occur in the same way as in an L.O.A. Flexion insures the occiput striking the pelvic floor in advance of any other portion of the head; hence this leading part is rotated forward through one-third of the circumference of the pelvis. The anterior shoulder lies opposite the pectineal eminence of the same side as that upon which the occiput originally was placed; as the occiput turns toward the symphysis this shoulder is obliged to swing across the pelvis toward the pectineal eminence of the opposite side on account of the severe torsion of the cervical tissues produced by such a long rotation of the occiput. In some cases, owing to delay in the establishment of good flexion, the anterior rotation of the occiput does not occur until the head is quite low in the pelvis. After the occiput has come under the symphysis the head is delivered by the movement of extension, and the subsequent steps of the mechanism are the same as in occiput anterior cases.

Anterior Rotation of the Sinciput.—From all posterior positions of the occiput the vertex must enter the excavation with the wide bi-parietal diameter occupying the sacro-cotyloid diameter of the pelvis, while the narrow bi-temporal lies in the roomy oblique diameter. If the back of the head becomes retarded, owing to the contracted sacro-cotytoid diameter, or if there be some abnormal relation between head and pelvis, an undoing of the flexion results, so that the sinciput descends to a lower level than the occiput, strikes the pelvic floor first and rotates under the symphysis. The occiput now is turned into the hollow of the sacrum, the forces on both sides of the head balance, and we have the position known as "occiput permanently posterior." Delivery takes place by the descent of the occiput along the posterior wall of the canal, which is so much longer than the anterior wall that the leading part cannot reach the vulva without drawing into the excavation a certain portion of the trunk of the fœtus. Flexion now becomes exaggerated as the child wedges itself into the pelvis with the sinciput jammed against the inner surface of the symphysis, and the cervico-bregmatic diameter, plus the thickness of the child's thorax, occupying the antero-posterior diameter of the excavation. Considerable power is required to drive the occiput to the vulva, and the uterus labors under the disadvantage of having a lessened amount of fœtus within its grasp; at the same time the fœtal curve does not coincide with the curve of the genital canal, the leading part pointing backward and tending to plough into the posterior wall. When the occiput reaches the vulva the perineum is pushed far back and frequently lacerated; the sinciput is released from under the pubis by extension of the head. *Restitution*, or the establishment of the normal relation between head and shoulders, takes place as usual, but it may be noted that *external rotation*, which depends upon the *internal* rotation of the shoulders, is from back to front instead of from front to back. The rest of the mechanism of delivery presents no peculiar features.

Conversion into a Face Presentation.—When the flexion is greatly disturbed by delay in the passing of the bi-parietal diameter complete extension may occur and a face presentation result, or the occipito-mental diameter may become wedged across the pelvis and further progress cease.

Prognosis.—As compared with anterior positions the labor is longer in cases of occiput posterior and intervention is more frequently required. The delay is chiefly in the first stage of labor, but the forward rotation of the occiput occurs in the vast majority of cases; according to Bataillard and Varnier, out of 400 cases of occiput posterior at the brim of the pelvis rotation failed to take place in but 6. When the state of things described as "occiput permanently posterior" develops the prognosis for the child becomes serious on account of the long-continued pressure and exaggerated flexion due to the impaction. For the mother there is greater danger of laceration of the soft tissues and she is involved in all the risks incident to long labors and operative interference.

Treatment.—During the last few weeks of pregnancy and early in the first stage of labor the postural treatment may be tried. This consists in having the woman assume the knee-chest position at intervals for as long a time as she can avoid fatigue, in order to allow the head to free itself from the pelvis and the weight of the spinal column to turn the occiput to the front. With the exception of the postural treatment there is nothing else to be done until the cervix is dilated. At the end of the first stage one of three courses may be followed: 1. The case may be *left to nature* when the patient is a multipara with a normal pelvis and fœtus, the history of previous labors being favorable. 2. *Manual flexion and rotation:* Under an anæsthetic the whole hand may be introduced into the vagina, the head lifted above the pelvic brim, flexed, and the occiput rotated into an anterior position. Unless an assistant at the same time turns the body of the child by external manipulation the torsion of the neck will cause the occiput to regain its posterior position as soon as the hand is withdrawn. After the occiput is brought into one of the anterior positions the forceps should be applied and the head drawn well down into the pelvis or completely delivered. 3. *Version:* Considerable skill is required to perform manual flexion and rotation; hence the inexperienced obstetrician will find internal podalic version an easier operation for the correction of occiput posterior. 4. In rare cases it might be advisable to extend the head and allow the labor to proceed as a face with chin anterior.

During the natural delivery of a vertex, occiput posterior, the physician should keep watch regarding the maintenance of flexion and, if necessary, make counter-pressure upon the sinciput. If the bi-parietal diameter becomes caught in the sacro-cotyloid so that the head tends to extend, interference according to one of the methods described above is called for. A head low down in the pelvis sometimes can be flexed by the application of reversed forceps, but if forceps be applied while the head is still at the brim the almost invariable result is to bring the occiput into the hollow of the sacrum. Under deep anæsthesia it is surprising from how low a position in the pelvis the head can be lifted and rotated when the operator is expert. The forcible rotation of the head while in the grasp of the forceps is a dangerous procedure although suggested by several writers. Forceps are often required for the extraction of the head after the occiput has become permanently posterior.

Face Presentations.—Face presentations are rarely

found before the onset of labor pains and are caused by conditions which allow or produce extension of the head, such as obliquity of the uterus, coiling of the cord about the neck, deformities of the head or pelvis hindering descent of the occiput, and excessive mobility of the fœtus due to small size or to a large quantity of liquor amnii. Face presentations are said to occur once in about two hundred and fifty labors.

Positions.—The fœtal denominator is the chin which may lie opposite one of the ilio-pectineal eminences or sacro-iliac synchondroses. The positions are designated as follows: R.M.P., right mento-posterior; L.M.A., left mento-anterior; L.M.P., left mento-posterior; R.M.A., right mento-anterior.

Diagnosis.—The face does not fit well into the pelvis, and consequently the fœtus lies higher in the abdomen than in normal presentations. If the chin be anterior the child's chest and extremities are in contact with the mother's abdominal wall and are easily palpated; the heart sounds are very distinct, being heard near the level of the umbilicus on the right or left side. When the chin is posterior, the extension of the head prevents a close relationship between the fœtal back and mother's abdomen, so that, as the hand follows down from the breech, the maternal tissues must be more and more depressed to reach the child. Low down the right angle formed by the occiput and back may be noted. On internal examination the high position of the presenting part is detected, and when the cervix is dilated the finger palpates the orbital ridges, nose, mouth, and chin. If the woman has been in labor some time, an extensive caput succedaneum may make it very difficult to distinguish between a face and a breech. In doubtful cases care must be taken lest the eyes be injured by the examining finger.

Mechanism.—As the head descends the extension becomes complete, so that the occiput is pressed against the child's back and the chin is made the leading part. The chin, therefore, is exposed to the forward thrust from the pelvic floor and rotated under the symphysis; the shoulders are now upon the pelvic floor and cannot descend further without rotation into the long diameter of the outlet. The head being the only part free to move flexion occurs, sweeping the occiput over the perineum and delivering in succession mouth, nose, sinciput, and occiput. Restitution and external rotation with delivery of the trunk occur in the same manner as in vertex cases. In chin anterior cases the rotation of the chin may be hindered by the occiput striking the promontory of the sacrum so that the face often descends quite low in the pelvis before turning. From a posterior position the chin must make a long turn, which is possible only through good extension, strong labor pains, and concomitant turning of the shoulders to relieve the torsion of the neck. When extension is deficient or the forces are abnormal, the sinciput may be turned forward and the condition of "chin permanently posterior" be established. Under the ordinary relations of fœtus and pelvis delivery is impossible with the chin permanently to the rear, as the distance between the thorax and point of chin is so much less than the length of the posterior wall of the canal that impaction develops before the chin can reach the vulva.

Configuration of the Head.—The moulding of the head during face labor produces a flattening of the vertex with bulging of the frontal and occipital bones; consequently the transverse, occipito-mental, and occipito-frontal diameters are increased in length while the suboccipito-bregmatic is diminished. The caput succedaneum forms over the malar region, about the eye and angle of the mouth, producing a very striking, though temporary, disfiguration. There may be an ecchymotic area where the occiput presses against the back.

Prognosis.—The fœtal mortality in face labor is much higher than in vertex, being placed at from ten to fifteen per cent. The dangers are the extreme extension of the head and the exposure of the anterior portion of the neck to pressure against the pelvic walls; as the face is a poor dilator the labor is apt to be long and prolapse of the umbilical cord is favored because of the irregular outline of the presenting part; the frequent necessity for operative interference is also injurious for the child. In neglected cases of "chin permanently posterior" the outlook for the child is wellnigh hopeless. For the mother the prognosis is unfavorable in proportion to the length of the labor and the operative measures required.

Treatment.—At the end of gestation, or during the first stage of labor, an effort may be made to correct the presentation by means of external manipulation. The method of Schatz consists in elevating the fœtus from the pelvis, flexing the trunk upon the head and then pressing downward upon the breech; an assistant meanwhile should aid in pressing the occiput away from the child's back. The substitution of a vertex presentation by means of external manipulation is possible only in cases in which the fœtus is quite movable and the maternal tissues are lax. If the face presentation is not diagnosed until labor is in progress, every care should be taken not to rupture the membranes until there is full dilatation of the cervix. When the bag of waters is large, owing to the fact that the face does not fit snugly into the pelvic brim, it is advisable to make counter-pressure by introducing the colpeurynter into the vagina. When the face is above the brim with the *chin anterior*, we have a choice of three courses: 1. The *delivery* may be *left to nature:* this is justifiable only when the patient is a multipara with a history of previous easy labors and when the fœtus is not above normal size. Good extension must be assured by making counter-pressure against the sinciput, and the finger or forceps blade may be applied behind the point of the chin when there are signs of delayed rotation. The fœtal heart must be frequently examined and the forceps applied whenever the indication arises, but the physician must remember that there is great danger of injury to the child's neck from the tips of the instrument. In leaving a face case to nature the physician takes upon himself a grave responsibility, and it is well to warn the family in advance of the dangers and of the temporary disfigurement of the child's face. 2. *Flexion and rotation.* This is the best treatment in the majority of cases; the flexion gives a vertex presentation, and manual rotation is necessary to correct the posterior position of the occiput. The mode of procedure is the same as that described in the section on "vertex presentations, occiput posterior." After correcting the presentation the forceps should be applied to draw down and fix the head. 3. *Version.* This operation is indicated when the physician desires to alter the presentation, but is unable to perform manual flexion and rotation.

Face Below the Brim, Chin Anterior.—Under these conditions the case may be left to nature; forward rotation of the chin may be delayed and require the assistance of the finger or forceps blade; delivery by forceps may be necessary.

Face Above the Brim, Chin Posterior.—In this position interference always is demanded, the proper treatment being manual flexion which gives a vertex with occiput anterior. After the flexion forceps may be applied if there is a tendency for the extension to recur.

Face Below the Brim, Chin Posterior.—This is a serious state of affairs. 1. Introduce the hand into the vagina, place the fingers behind the chin and attempt to rotate it forward. Some authorities advise grasping the face in the forceps and attempting anterior rotation; this is very dangerous and no one but an expert should attempt it. 2. Elevation and flexion: if the uterus is not in a state of tetanus it may be relaxed under deep anæsthesia sufficiently to allow the hand to elevate and flex the head. It often is astonishing how readily the head may be lifted to the pelvic brim, even when low down, provided the patient is deeply anæsthetized. 3. If procedures Nos. 1 and 2 fail *craniotomy* is indicated if the child be dead, but if it be alive the claims of *symphyseotomy* must be considered.

Brow Presentations.—These presentations are rare and may be looked upon as *partial face,* the head being in an attitude midway between extension and flexion.

Brow labors occur once in about two thousand cases, for the first contractions of the uterus usually complete the extension or flexion.

Diagnosis.—By external palpation the case would have the features of a face presentation; internal examination would show the forehead and anterior fontanel occupying the centre of the pelvic inlet.

Mechanism.—As the attitude of the head brings the largest cephalic diameters into the pelvic planes spontaneous delivery is possible only when the pelvis is roomy and the fœtus small. The brow rotates to the front so that the face comes to lie against the inner surface of the symphysis. By a movement of flexion the occiput sweeps over the perineum, then by extension the face is freed from under the symphysis. Spontaneous delivery of brow permanently posterior is impossible.

Head Moulding.—After brow labor the head is somewhat triangular in shape, the occipito-mental diameter being markedly diminished. The caput succedaneum occupies the forehead.

Prognosis.—The mortality of the children is placed as high as thirty per cent. The outlook of the mother depends upon the nature of the labor and the operative procedures involved.

Treatment.—When diagnosed early in labor a brow presentation always should be corrected. When the occiput is anterior manual flexion is the best treatment, as the result is vertex in a favorable position. If the occiput is posterior, extension will give a favorable position of the resulting face presentation, whereas flexion must be supplemented with manual rotation of the occiput forward. When the head has become moulded and the brow presentation tends to recur version should be performed. In an impacted brow case with the forehead anterior a cautious trial of the forceps may be attempted, but craniotomy or symphyseotomy is often necessary. When the head is wedged with the forehead in the sacrum, craniotomy is indicated.

Pelvic Presentations.—There are four varieties of pelvic presentations: 1. The breech may present with the thighs flexed upon the trunk and the legs upon the thighs. 2. The legs may be extended along the length of the anterior surface of the child's body. 3. The thighs may be extended and the legs flexed, forming a knee presentation. 4. Both thighs and legs may be extended downward, giving a footling presentation. There may be various combinations of the above.

Etiology and Frequency.—Pelvic presentations are caused by alterations in the relation between the fœtal and uterine ovoids. Hydrocephalus and multiple pregnancy may alter the shape of the fœtal ovoid; the shape of the uterus may be changed by laxity of tissue, excess of liquor amnii, tumors, contracted pelvis, and placenta prævia. Including cases of premature labor pelvic presentations occur once in thirty deliveries, but only once in sixty if none but full-term cases are included. The higher percentage in premature cases depends upon the fact that before the end of gestation the bulk of the fœtus is small relative to the size of the uterine ovoid.

Positions.—The fœtal denominator is the sacrum and the positions are as follows:

R.S.A., right sacro-anterior, L.S.P., left sacro-posterior,	Bitrochanteric diameter in R. oblique.
L.S.A., left sacro-anterior, R.S.P., right sacro-posterior,	Bitrochanteric diameter in L. oblique.

Diagnosis.—On abdominal palpation the head is felt in the upper part of the uterus as a large, hard, round, movable body; the depression marking the site of the neck can be detected. On following down the fœtal trunk the breech and small parts may be found at the brim of the pelvis. The fœtal heart sounds are best heard over the child's back above the level of the umbilicus. On vaginal examination the presenting part is found high up and, if the cervix be dilated, the sacrum, coccyx, and ischial tuberosities may be felt. The depressions between the buttocks and the genital organs often are easy to distinguish. To differentiate a buttock from a shoulder, the finger should be passed into the groin and the absence of ribs noted. The projection of the heel, the malleoli, and the parallel toes are the marks by which a foot is distinguished from a hand. The presence of the patella enables one to diagnose a knee from an elbow. During the second stage of labor meconium may be discharged on account of the pressure to which the child's body is exposed.

Mechanism.—The first stage of labor may be prolonged as the soft breech seems to be an inefficient irritant to uterine contraction. Often the bag of waters is large and therefore tends to rupture before the cervix is completely dilated. As the breech descends the anterior hip is the lower and therefore rotated to the front under the symphysis; the posterior hip sweeps over the perineum. When both hips are at the vulva there results a lateral curvature of the child's trunk, as the upper portion still is in the axis of the superior strait. The shoulders enter the pelvis in the same oblique diameter as the hips and rotate into the antero-posterior diameter of the outlet. When the trunk is delivered as far as the scapulæ, the flexed head enters the plane of the pelvic brim with the suboccipito-bregmatic diameter occupying an oblique diameter opposite to that traversed by the hips and shoulders. The projecting occiput strikes the pelvic floor and rotates to the front, the face looking into the hollow of the sacrum. The head is delivered flexed, the chin, nose, forehead, and, finally, the occiput being born. In rare instances the occiput turns backward instead of forward; the head is now delivered by one of two mechanisms. If flexion is maintained the delivery is like the one already described, except that the face slips out from under the symphysis instead of over the perineum. If the chin should catch upon the top of the symphysis extension occurs until the face comes to look directly upward; in this attitude the occiput is the first part of the head born and the face the last. In some instances the legs extended alongside the trunk act as splints and hinder the descent of the breech by preventing lateral flexion of the child's body.

Prognosis.—The labor is longer and the risk to the fœtus twice as great in breech labors as in vertex. The dangers to the fœtus lie in the unavoidable compression of the cord between the pelvic walls and after-coming head, in the possibility of an insufficiently dilated cervix causing constriction about the child's neck, in asphyxiation resulting from premature efforts at respiration. Rapid extraction may produce fractures or dislocations of the limbs. Even in good hands a number of children are lost and sometimes resuscitated infants die a few days later from bronchopneumonia due to the inspiration of foreign matter. The prognosis for the mother is not much affected by a breech labor unless artificial extraction is necessary and the soft tissues are lacerated.

Management.—At the end of pregnancy or very early in the first stage an effort may be made to substitute a cephalic presentation by performing external version. If this treatment succeeds, which is rarely the case, pads should be applied to the sides of the abdomen to prevent recurrence of the original presentation. In the management of breech labor the physician must be extremely careful not to interfere unless the indications are clear. During the first stage premature rupture of the membranes must be avoided, for the breech may not cause sufficient dilatation for the passage of the head through the cervix. When the bag of waters is very large, counter-pressure by means of the colpeurynter is a wise precaution. When the second stage is in progress it is well to have a competent assistant present, the forceps ready, a warm blanket for wrapping about the child, and all the conveniences for resuscitating asphyxiated infants. During the descent of the hips the physician should frequently examine the fœtal heart. As the presenting part nears the vulva, the patient should be placed in the lithotomy position across the bed or, preferably, upon a table. As the trunk is born it is protected from the action of the cool air by being wrapped in the blanket; as soon as the umbilicus appears, the cord is placed as far back in the pelvis as possible to escape compression.

While the attendant supports the body of the child, the assistant maintains firm pressure upon the uterus in order to prevent the slipping upward of the arms and the undoing of the flexion of the head. If there be delay in the descent of the head, the child should be made to straddle the physician's left arm while the fingers of the left hand are passed up to the child's mouth or superior maxilla and used to maintain the flexion; the fingers of the right hand are placed over the shoulders and traction is made directly downward until the chin reaches the vulva, when the child's trunk is elevated to enable the face to sweep over the perineum. When the mouth has been brought to the outlet there is no need for haste, and the attendant can preserve the soft tissues by slow extraction of the head. Cessation of the pulsation in the cord, or premature efforts at respiration, calls for immediate delivery. The most serious mistake which can be made is to exert traction upon the child's trunk, as extension of the arms and head will probably be the result and the consequent delay in extracting the head be fatal. The vast majority of cases call for nothing beyond counter-pressure over the uterus with support of the trunk and maintenance of flexion.

Impaction of the Breech.—If the breech is low down the finger may be hooked into the groin and traction made. When the finger cannot be employed a gum-elastic catheter can be threaded with a double loop of silk and passed over the groin; the loop is caught with the finger, drawn down, and used to carry back a fillet made of tape or narrow gauze. The traction upon the fillet should be almost directly downward. The forceps also is applied to the breech in cases of impaction, but it is very apt to slip.

Extension of the Legs Along the Trunk.—If this attitude of the limbs hinders descent by preventing lateral flexion, the hand must be passed up and the legs flexed and drawn down.

Extension of the Arms and Head.—Arms extended alongside of the head are freed in the manner described under the head of version and extraction. Flexion of the head can sometimes be re-established by pushing the child upward, passing the fingers up to the mouth, rotating the head into the transverse diameter, and making traction. In cases of delivery of face to the pubes the child's body is swung in a direction opposite to that followed when the occiput is anterior.

Transverse Presentations.—In these presentations the axis of the fœtus forms an angle with the longitudinal axis of the uterus. The great majority of these presentations are shoulder presentations and will be treated under that heading. In rare instances the examining finger impinges upon the ventral or dorsal aspect of the child.

Causes of Transverse Presentations.—The causes are much the same as those producing pelvic presentations; alteration in the shape of the uterus from tumors, pendulous abdomen, or excessive amount of liquor amnii, deformed pelvis, and fœtal monstrosities are the most worthy of mention. Transverse presentations occur in less than one-half of one per cent. of labor cases.

Position.—Shoulder presentations are described by stating whether the head is right or left and the back in front or behind; hence we have:

Head to the right.
1. Dorso-anterior.
2. Dorso-posterior.

Head to the left.
1. Dorso-anterior.
2. Dorso-posterior.

Diagnosis.—On inspection and palpation the long diameter of the uterus is not longitudinal with the mother's abdomen and the head is felt in one or the other iliac fossa; the heart sounds are best heard below the level of the umbilicus. On internal examination the presenting part is high; the point of the shoulder is characterized by the presence of the clavicle and scapula; the finger may enter the axilla and distinguish the ribs; the arm may be followed out until a hand is reached. In some cases the hand or elbow is prolapsed.

Prognosis.—Neglected shoulder presentations offer an unfavorable prognosis for both mother and child, for if left to nature the uterus contracts down upon the fœtus in a condition of tonic spasm, destroying the child's life and threatening the mother with the dangers of rupture of the uterus, post-partum hemorrhage, and sepsis.

Mechanism.—There are two mechanisms by which shoulder presentations are sometimes spontaneously delivered, but they occur so infrequently that they have not the least bearing upon treatment.

1. *Spontaneous Version.* The uterine contractions gradually force one or the other fœtal pole into the superior strait.

2. *Spontaneous Evolution.* The fœtus is doubled upon itself until the breech and lower extremities of the child are able to sweep by the head which is delivered last.

Treatment.—All shoulder presentations call for interference. Very early external cephalic version may be possible in some cases, but the usual treatment is internal podalic version except when the uterus is in such a state of spasm that there is danger of rupture; in which event decapitation is the safer procedure.

Prolapse of the Limbs.—Prolapse of the limbs alongside of the presenting part may affect the mechanism by producing impaction or faulty rotation. Irregularities in the outline of the pelvic brim constitute a predisposing cause of such prolapse.

1. *In Head Presentations.* One or both hands may prolapse alongside of the head and prevent descent or cause the chin or occiput to rotate into the hollow of the sacrum.

If the diagnosis be made in the first stage of labor nothing should be done until the cervix is dilated. An effort then may be made to replace the prolapsed limb or limbs and the head drawn down by forceps. If replacement or forceps fail version is indicated. The treatment is the same when the foot is prolapsed.

2. *In Breech Presentations.* A prolapsed hand is of very little import; it usually slips up as the breech descends, although that is of little moment as the presenting part is compressible and requires less space than does the head.

3. *In Transverse Presentation.* A prolapsed foot simplifies the performance of version. A hand may be secured by a piece of tape about the wrist so that it can be drawn to one side and prevented from ascending as the child is turned. *Montgomery A. Crockett.*

LACHRYMAL APPARATUS, AFFECTIONS OF.—The lachrymal apparatus consists of two distinct parts—the lachrymal gland, described by anatomists as divisible into an orbital and a palpebral portion, divided by a fibrous septum, which lies in a fossa just within the upper margin of the orbit near to its outer angle, and which has for its function the secretion of the tears; and the puncta, the canaliculi, the lachrymal sac, and the nasal duct, which together form the drainage system of the eye, carrying away the tears from the neighborhood of the inner canthus, where they tend to accumulate after having accomplished their purpose of moistening the conjunctival sac. It is commonly taught that under ordinary conditions the lachrymal gland is quiescent, and that it is only in response to some unusual stimulus that it becomes active and secretes tears. It seems probable, however, that this view is incorrect; for in occlusion of the nasal duct the lachrymal sac soon refills with tears after having been emptied by pressure, even when there is no inflammation of the eye or of the sac to act as a special stimulus. It is held by some that it is chiefly, if not solely, the palpebral portion of the gland which secretes habitually; but, whether this be true or not, there seems to be little room for doubt that, at least when the eyes are open and in use, there is a constant, though slight, flow of tears, which disappear in part by evaporation from the surface of the eye, and in part by evaporation from the mucous membrane of the nostril after

having passed through the nasal duct.* In order that the drainage of the eye shall be perfect, it is essential not only that the puncta and the lachrymal canals shall be pervious, but that the eyelids shall be in such position that the puncta are in apposition with the ball, otherwise the tears fail to find their way into the canaliculi. The lachrymal gland is, comparatively speaking, rarely the seat of disease; affections of the drainage apparatus are, on the other hand, of very common occurrence.

AFFECTIONS OF THE LACHRYMAL GLAND.—*Luxation of the lachrymal gland,* though from its protected position it is little exposed to external violence, has happened in

FIG. 3096.—Hypertrophied Lachrymal Gland.

a few instances, but is an accident of extreme rarity. *Neuralgia of the gland* has also been observed, and the name "*dacryoadenalgia*" was given to it by A. Schmidt, who first described it. Severe lancinating pain in the region of the gland, intolerance of light, and excessive lachrymation are the symptoms which characterize it. It is said to occur most frequently in children, and in women in the puerperal state; also in gouty subjects. It is liable to become chronic, and relapses are apt to occur. In this country, at least, it is a very uncommon affection, and the writer, if he has met with such a case, has failed to recognize it. The application of moist heat is recommended as a useful remedy. The oleate of morphine, or of morphine and atropine, or of morphine and cocaine, to be rubbed upon the brow and lid, or a lotion of belladonna or of opium, to be applied over the closed lids, suggest themselves as the local remedies from which most benefit might be expected. Constitutional treatment also should not be neglected.

Simple *hypertrophy of the lachrymal gland* is occasionally met with. It is said to occur most frequently in children, and may even be congenital. The gland may in time become so large as to force the eye from the orbit, and, by pressure upon its nutrient vessels and traction upon the optic nerve, to destroy sight. Cases have been observed, however, in which there was great displacement of the eye, with an astonishing amount of elongation of the optic nerve and the external muscles of the globe, and yet a fair amount of sight and ability to rotate the eye in various directions were retained. The accompanying illustration (Fig. 3096), which is an accurate reproduction of a photograph of the patient, represents a remarkable case of this character which came under the observation of Prof. Christopher Johnston, of Baltimore, in 1876. Notwithstanding the great displacement of the eye its movements were retained, and there was a visual acuteness equal, at least, to counting fingers. Professor Johnston removed the greatly hypertrophied gland, and the eye gradually became retracted into the orbit until it finally resumed nearly its normal position. This is the only plan of treatment likely to prove effectual in cases of this character, and, to prevent impairment of vision, resort to it should not be too long delayed. In the condition known as xerophthalmia the atrophic process is said to extend, in some instances, from the conjunctiva to the lachrymal gland, which undergoes *atrophy* and ceases to secrete tears.

Dacryoadenitis, or inflammation of the lachrymal gland, is another affection which is seldom encountered. In explanation of this fact Power remarks:* "It is not difficult to assign reasons why inflammation of this gland should be of exceptional occurrence, for it occupies a position that is remarkably protected both from injury and from cold. Then, again, the product of its secretion is of so limpid and watery a character that concretions from inspissation or deposition are extremely rare; while it is discharged by ducts which, though very fine, are yet numerous, and perhaps communicate, so that there is little risk of the secretion being retained." In proof of the rarity of this disease, he mentions that Arlt states he has never seen a case of it; that Desmarres makes the same observation; that Hirschberg, among 22,000 cases of disease of the eye, saw but one case of suppurative dacryoadenitis; and that in the indices of the "Royal London Ophthalmic Hospital Reports," there occurs only one case of abscess of the lachrymal gland. On the other hand, however, it is to be remarked that the diagnosis of this affection is not always an easy matter, and that it is probable that it has not infrequently been mistaken for simple orbital cellulitis. Galezowski has pointed out that dacryoadenitis sometimes assumes an epidemic character, and he states that he met with an unusual number of cases during an epidemic of mumps.

There are two varieties of inflammation of the lachrymal gland—a chronic form, which is the more common, and an acute variety, in which there may be a rapid formation of pus, or a resolution of the inflammation, without the occurrence of suppuration. In the chronic form the gland becomes more or less enlarged, and may be felt as a "firm, nodulated, immovable swelling at the upper and outer margin of the orbit." The upper lid is usually somewhat swollen and red, and the conjunctiva, especially in the superior retrotarsal fold, is injected. Pain is not a prominent symptom. Displacement of the eyeball downward and inward, with impairment of its mobility, may occur if the swelling of the gland be considerable. In the acute variety there is severe pain in the region of the gland, accompanied by redness and œdema of the upper lid. The gland itself becomes greatly enlarged, and in consequence the eyeball is displaced, and a squint is produced which may be accompanied by diplopia; the movements of the eyeball are also attended by pain. It is possible, at the beginning of the attack, to recognize the firm resistant border of the swollen gland, and by raising the upper lid to see it projecting into the conjunctival sinus; but the swelling of the lid which supervenes soon prevents the gland from being either felt or seen (Power). There is usually congestion and, in the neighborhood of the gland, chemosis, of the conjunctiva. Cerebral excitement, sleeplessness, and delirium are mentioned by some authors as occurring in the more severe cases, and are ascribed, in part, to implication of the dura mater. If suppuration supervene, which it may do within a few days, the pus may make its way to the external surface of the lid, or it may be discharged into the conjunctival sac. Usually the inflammation is unilateral, but both glands are sometimes simultaneously affected. The causes which are supposed to be capable of exciting inflammation of the lachrymal gland are various—traumatism, "cold," rheumatism, gout, struma, syphilis, mumps, influenza, leucocythæmia, tuberculo-

* It is a common observation, with persons who have occlusion of one nasal duct, that the corresponding nostril is drier than the opposite one. This difference would hardly be remarked unless the nostril were habitually moistened by a constant flow of tears.

* In a very interesting lecture upon "Affections of the Lachrymal Apparatus," published in the London Lancet, July 31st, 1886.

sis,* and the extension of inflammation from the cornea and conjunctiva, are among those which have been assigned. The treatment will, of course, vary with the character of the attack and the circumstances which have given rise to it. In the chronic form benefit may be expected from the local application of mercurial ointment, oleate of mercury, or compound iodine ointment; or an ointment of iodoform or of iodol may be tried. Mercury, iodide of potassium, salicylate of soda, quinine, and iron are the constitutional remedies which are most likely to be useful. Extirpation of the gland may be required, if it should become so enlarged as to endanger the integrity of the eye. In the acute variety, if there is hope of cutting short the attack, leeching should be resorted to, and a lotion of acetate of lead and opium should be applied externally, while, internally, a brisk calomel purge should be given, to be followed by the liberal administration of quinine, salicylate of soda, or pyrophosphate of soda. Opium or chloral may be required for the relief of pain. Warm fomentations should take the place of the lead-and-opium wash if it becomes manifest that suppuration is to supervene; and when pus can be detected, a free incision should be made through the upper lid to permit of its escape. Some authorities recommend that the incision should be made beneath the upper lid, but the swelling of the parts makes this difficult of accomplishment.

It sometimes happens, after suppurative inflammation of the lachrymal gland, that a fistulous opening is left in the integument of the lid, through which there is a constant and annoying discharge of tears. Such *lachrymal fistulæ* are difficult to cure, and it is not always safe to attempt their closure, as this may be followed by a fresh attack of inflammation of the gland. Necrosis of the margin of the orbit and of the orbital plate has been known to occur as a result of severe inflammation of the gland, and temporary fistulæ may be produced in consequence.

From obstruction of one or more of the excretory ducts, *cyst of the lachrymal gland*, termed *dacryops*, is occasionally formed. Upon everting the lid it may be seen as "a bluish-pink, semitransparent, elastic, and somewhat fluctuating swelling, consisting, perhaps, of several nodulated segments of varying size. . . . The swelling, moreover, increases suddenly and markedly in size if the patient cries, or the secretion of tears is stimulated by the application of some irritant to the conjunctiva" (Soelberg Wells). The wall of the cyst is so delicate and ill-defined that it is impossible to dissect it out. The treatment which has proved most successful is the establishment of an artificial opening between the cyst and the conjunctival sac, which may be done either by making an incision from the conjunctiva through the anterior wall of the cyst, and keeping the edges apart by the daily introduction of a probe until they have healed; or, as von Graefe suggested, by introducing a suture through the wall of the cyst, tying it loosely, and allowing it to cut its way out.

In rare instances chalky concretions known as *dacryoliths* are found in the lachrymal gland. If so situated as to cause irritation, they should be removed by incision through the conjunctiva. *Tumors* of the lachrymal gland are rare. The following varieties, believed to have had their origin in the gland, have been observed: Adenoma, myxoma, myxo-sarcoma, lympho-sarcoma, spindle-cell sarcoma, epithelioma, cylindroma, chloroma, and carcinoma. As soon as the diagnosis can be established complete extirpation of the gland should be practised. This may be accomplished by means of a free incision through the skin and fascia of the upper lid, close to the margin of the orbit, or the outer canthus may be divided, and the gland removed through an incision in the superior conjunctival cul-de-sac.

Affections of the Drainage Apparatus.—Although the secretory portion of the lachrymal apparatus is so rarely affected by disease, those parts which have to do with the drainage of the eye are very frequently, as has been said, the seat of pathological changes. There is a twofold reason for this—first, the mechanism by which the tears are carried from the conjunctival sac to the nose is somewhat complex, and a disarrangement of any one of its parts is likely to disturb the normal action of the whole; and, second, the whole drainage apparatus, while an appendage of the eye, is, pathologically considered, a part, rather, of the nasal cavity, and it is a question whether, under the conditions of modern civilization —paradoxical as the statement may appear—a perfectly healthy state of the latter is not an abnormal state. Whatever may be the nature of the pathological changes which affect the drainage apparatus, or wherever they may be located, a common symptom characterizes them all: the passage of the tears into the nose is more or less completely interrupted, and, in consequence, they overflow the lids. This is the condition known as *epiphora* or *stillicidium lacrimarum*, which is not only in itself very annoying, but frequently gives rise to chronic conjunctivitis, blepharitis, and even to eczema of the lids and cheek.

Considering, in their anatomical order, the several conditions which may cause epiphora, we have, first, *occlusion of the puncta* (the closure of the lower punctum probably producing more disturbance than that of the upper), an affection of not very common occurrence, and *malposition of the puncta*, a condition which may be brought about by a variety of causes, and which is much more frequently encountered. The effect of each of these conditions, which are often associated, is the same—the tears are prevented from gaining entrance to the canaliculi. Complete obliteration of the punctum rarely happens, except, perhaps, as the result of traumatism (laceration, burn, or injury of the lid from some destructive chemical agent), or of inflammation attended by necrotic changes involving the tissues in its neighborhood. More or less complete occlusion, especially of the lower punctum, is, however, a common result of ectropion, and, indeed, of any condition which causes the punctum to turn outward, and so not only prevents the tears from entering it, but brings about a desiccation of the parts. Under such circumstances the mucous membrane lining the punctum becomes dry and cuticle-like; the opposite walls of the orifice adhere; and a layer of epidermis, continuous with that of the external surface of the lid, forms over it. In this condition it is not always easy to ascertain the position of the occluded punctum (though it is usually indicated by a slight depression); but, when it can be found, there is generally little difficulty in reopening it, the best instrument for the purpose being a straight, rather sharp-pointed probe (Fig. 3100), which, with a drill-like motion, can be made to penetrate the newly formed epidermis, and enter the still patent canaliculus. When there is complete obliteration of the orifice this method is not likely to be successful. By putting the lid upon the stretch we may, however, succeed in entering the canaliculus, near the punctum, with a sharp-pointed knife, and, having satisfied ourselves that we have accomplished this by passing a fine probe along the canaliculus into the lachrymal sac, we can then introduce Weber's probe-pointed knife, and slit the canaliculus throughout its whole length. The cut margins will have to be separated every twenty-four or forty-eight hours for three or four days, by which time they will have cicatrized, and henceforth the tears will find their way into the lachrymal sac through the divided canaliculus. Another method of dealing with such cases, proposed by Mr. Streatfield, is to slit the upper canaliculus, and to pass a small, properly bent probe through this aperture into the lachrymal sac, and then along the lower canaliculus to the occluded punctum. If practicable, the point of the probe is then to be forced through the obstruction, or, if this cannot be done, it is to be cut down upon. Afterward the lower canaliculus may be slit in the manner described.

There are several malpositions which the puncta may

* For an interesting paper by Dr. Edward Stieren upon "Tuberculous Dacryoadenitis and Conjunctivitis," with references to the literature of the subject, see the Johns Hopkins Hospital Bulletin for November, 1901.

assume (the lower one especially), that give rise to epiphora by preventing the tears from entering the canaliculi. They may be more or less completely everted, so that they no longer lie in contact with the eyeball; they may be so strongly inverted that a similar effect is produced; or, owing to the small size of the eyeball or its sunken position, they may lie away from it, a narrow, triangular space intervening, in the neighborhood of the inner canthus, between the lids and the front of the eyeball. Eversion of the punctum is a usual accompaniment of the different varieties of ectropion. It may also be produced by chronic inflammation of the margin of the lids, and is frequently present in paralysis of the facial nerve. In persons advanced in life it is often met with as one of the evidences of senile decay, being due to relaxation of the tissues of the lid and loss of tone of the orbicularis muscle. The epiphora which accompanies eversion tends to aggravate the malposition of the punctum, for it is apt to excite an eczematous inflammation of the external surface of the lid, which, by inducing further contraction, increases the ectropion. Inversion of the punctum is usually due to entropion, and is not infrequently one of the later consequences of chronic trachoma.

FIG. 3097.—Weber's Canaliculus Knife.

The remedy for all malpositions of the puncta is the operation, devised by Bowman, of slitting the canaliculus. There are several methods of performing this little operation (which can be done almost painlessly under the influence of cocaine), and a variety of instruments have been contrived for the purpose. In the writer's opinion, the best plan is to use the beak-pointed knife of Weber (Fig. 3097), or one of its many modifications. The lid should be put well upon the stretch while the knife is being introduced and the section completed, and care should be taken to hold the edge of the blade in such a way that the gutter made by the division of the canaliculus shall present rather toward, than away from, the eyeball. This precaution is not infrequently disregarded, and in consequence there not only results a conspicuous deformity, but the purpose of the operation is less perfectly accomplished. The effect of this simple surgical procedure, when properly done, is in most cases very gratifying; not only is the epiphora cured, but the palpebral conjunctivitis and blepharitis which it induces disappear, and the malposition of the lid margin is corrected or, at least, improved. This commendation, it may be remarked, applies more especially to the slitting of the *lower* canaliculus. The division of the upper canaliculus is an operation which the writer has very rarely found necessary. If it is impossible to gain entrance to the lachrymal sac by way of the lower canaliculus, or to restore its permeability, we may operate upon the upper one; but otherwise there seems to be no advantage in doing so. When the eversion of the lower punctum is considerable, and is only partially remedied by the simple division of the canaliculus, we may increase the effect by excising the posterior wall of the latter, with a small piece of the adjoining conjunctiva, as suggested by Critchett. As a rule, the edges of the divided canaliculus show but slight tendency to reunite, and, if separated once or twice, will cicatrize and remain apart. In exceptional instances, however, they adhere and re-adhere in a most persistent manner. When this happens the difficulty can usually be overcome by the excision of the posterior lip of the canaliculus, as just described. After division of the canaliculus for malposition of the punctum, an astringent collyrium is usually required to facilitate the cure of the attendant conjunctivitis. A solution of sulphate of zinc (gr. ss.-i. to ℥ i.), or of alum (gr. i.-ij. to ℥ i.), or a combination of either of these astringents with boracic acid (gr. x. to ℥ i.), answers well for this purpose. If blepharitis also be present, an ointment of yellow oxide of mercury (hydrarg. ox. flav., gr. ij. to "vaseline cerate," or ung. aquæ rosæ, ʒ i.) should be prescribed, and the margin of the lids should be touched occasionally with a crayon of nitrate of silver.

The puncta may be pervious and in normal position, and yet the tears may fail to reach the lachrymal sac because of *occlusion of the canaliculi.* Extensive obliteration of the canaliculus is usually of traumatic origin, but localized strictures may occur in consequence of plastic inflammation arising in other ways. The obstruction may be situated in any part of the canal, but is most apt to be near its inner extremity, either at the point where the upper and lower canaliculi join, or at the juncture of the common canal with the lachrymal sac. It is difficult to cure such strictures simply by probing, as they are very apt to re-form. The best plan is to slit up the canaliculus, preceding the introduction of the knife by the forcible passage of a fine, stiff probe, and being careful, if possible, to get the beak of the knife well into the lachrymal sac. If the probe cannot be made to enter the sac, a sharp-pointed knife must be employed instead. When both canaliculi are extensively obliterated, it is difficult, and may be impossible, to restore a permanent passageway for the tears.

Foreign bodies, especially loose eyelashes, are liable to find their way through the puncta into the canaliculi, where they excite irritation and obstruct the passage of the tears. If possible, they should be extracted through the punctum; but, if this cannot be done, their removal may be accomplished by slitting the canaliculus. *Dacryoliths* occasionally form in the canaliculi, and small *polypi* may develop in them. Dacryoliths are commonly due to the presence of a vegetable fungus (leptothrix), which, as it grows, distends the canaliculus, and may project through the punctum. In order to remove these growths completely, division of the canaliculus may be necessary.

Dacryocystitis.—The lachrymal sac, into which the canaliculi empty, and which is continuous below with the nasal duct, is frequently the seat of inflammation. An uncomplicated, primary inflammation of the lachrymal sac is, however, not often encountered. In a very large majority of cases the inflammation is secondary to, and dependent upon, disease of the nasal duct. Primary inflammation of the sac is oftenest met with in the newborn, usually in the form of a mild blennorrhœa; it also occurs in strumous children, and it may be produced by external violence—for example, a blow upon the eye—

FIG. 3098.—Case of Acute Dacryocystitis.

or by the entrance into the sac of an irritant fluid. The usual cause of dacryocystitis, however, is stricture of the nasal duct. When this condition exists tears, mucus, and epithelial débris accumulate in the lachrymal sac and form an excellent medium for the growth of invading

bacteria. In this way there is set up a chronic catarrhal inflammation, or blennorrhœa, which may last for years, the sac being constantly distended with muco-purulent matter, which oozes out through the puncta and spreads over the eye, obscuring vision, or mixes with the tears, to overrun the lid, and so increases the annoyance of the stillicidium.

The individual who suffers in this way is fortunate, however, if he does not experience a periodical aggravation of his troubles; for in chronic blennorrhœa of the lachrymal sac acute exacerbations of the inflammation are by no means unusual, while conjunctivitis and keratitis are complications which may occur at any time. Acute dacryocystitis, or abscess of the sac (Fig. 3098), as it is termed, is a serious malady; at least, it is attended by intense suffering and at times by very considerable constitutional disturbance. The swelling which accompanies it is not confined to the region of the lachrymal sac, but involves the lids and cheek; indeed, the whole side of the face may be swollen, œdematous, and red, so that the appearance presented is not unlike that of facial erysipelas, for which it is often mistaken. If the inflammation is allowed to run its course, the sac becomes distended by pus which after a time makes its way through the walls and finally through the external integument. After this has occurred the acute symptoms subside, and usually the parts return to their former condition. It may happen, however, that the external opening through which the pus has found exit fails to heal, because of the constant passage through it of tears and mucus, and there is then established the condition known as *fistula lacrimalis.*

It follows, from what has been said regarding the etiology of inflammation of the lachrymal sac, that the treatment of this affection—at least of the chronic variety of it—is, practically, the treatment of stricture of the nasal duct, and of this we shall speak presently. A few suggestions may be offered here, however, in regard to the *treatment of acute dacryocystitis.* It does not often happen that cases of this character are seen early enough to enable us to cut short the attack by antiphlogistic measures; but when it does, every effort should be made to bring about this result. The abstraction of blood by leeches, the application of a lotion of lead and opium (ext. opii, gr. x. to xv.; plumb. acetat., gr. xv.; aquæ destill., ℥ iv.), and the administration of a brisk calomel cathartic, to be followed by liberal doses of pyrophosphate of soda (gr. xv. to xx. every two or three hours), are the measures which are most likely to prove effectual. If these measures fail to subdue the inflammation, warm flaxseed-meal poultices, or, better still, a pad of gauze wet with a lotion of opium and boracic acid (ext. opii, gr. x.-xv.; acid. boracic., gr. lx.; aq. destil., ℥ iv.) and covered with a piece of rubber protective to prevent evaporation (a cleanly and convenient substitute for a poultice), should be applied constantly, and as soon as fluctuation can be detected, or it is evident that pus has formed and is endeavoring to make its way to the surface, vent should be given it by an incision through the integument and the anterior wall of the sac. As such an incision leaves no perceptible scar (provided it is made in the direction in which the skin tends to wrinkle, that is, from above and toward the nose downward and outward), it is much better to give the pus free exit in this way than to attempt to drain the sac by slitting the canaliculus.

The close relationship which exists between affections of the nose and disorders of the drainage apparatus of the eye has already been alluded to. This, as might be expected, applies especially to pathological states of the nasal duct; for this canal, which is continuous above with the lachrymal sac, and empties below into the inferior nasal fossa, is in reality almost a part of the nose cavity itself. The membrane which constitutes its walls is continuous with the lining membrane of the nose, and, like the latter, is extremely vascular, contains erectile tissue, and is at once both a periosteal and a mucous membrane. It is then no matter of wonder, since nasal catarrh is so common a condition, that catarrh of the lachrymal duct should also be of frequent occurrence, and, in view of what has just been stated as to the histological peculiarities of the tissues which compose the membranous canal, it is not surprising that an inflammation commencing here as a simple mucous catarrh should often lead to stenosis of the duct, and ultimately to the formation of periosteal or bony strictures; for, owing to the vascularity of the parts and the erectile character of the submucous tissue, it is manifest that even a slight inflammation must be attended by marked engorgement and tumefaction, which will quickly lead to obliteration of the cavity of the duct. And it is further evident that this temporary occlusion, by causing retention of tears, will tend to aggravate and prolong the inflammatory process. And so what was at first simply a catarrhal process becomes presently a periosteal inflammation, attended by plastic effusion, which leads ultimately to permanent stenosis of the duct. The usual sequence of events in obstructive lachrymal disease is, first, nasal catarrh, with secondary involvement of the lachrymal duct; in consequence of this, temporary occlusion of the duct followed by periostitis, and ultimately by permanent stricture; then, persistent blennorrhœa of the lachrymal sac, culminating at intervals in acute outbreaks of inflammation, which may give rise to lachrymal fistula. If it be added that obstinate conjunctivitis and ulcerative or suppurative keratitis are complications of not infrequent occurrence, and that when stenosis of the lachrymal duct is once established it never undergoes spontaneous cure, but, with all its unpleasant consequences, lasts for a lifetime, we shall have a fair comprehension of this troublesome affection, which surgeons have for so long regarded with interest, and in the treatment of which they have expended so much ingenuity. It is doubtless true that inflammation of the lachrymal sac and stricture of the duct do not always arise in this manner, for we meet with cases that are clearly of traumatic origin, in which the starting-point of the trouble is, perhaps, a blow upon the bridge of the nose or over the region of the lachrymal sac; and, moreover, it is commonly taught that inflammation of the ocular membranes may extend to the lachrymal passages: but, in the writer's opinion, the pathogenesis of a very large portion of these cases is such as has just been described. How slight a tendency inflammation of the conjunctiva has to involve the lachrymal passages is shown by the fact that in so virulent a disease as gonorrhœal ophthalmia dacryocystitis scarcely ever occurs.

The history of the *treatment of stricture of the nasal duct*, if fully written, would fill a volume of no mean proportions. Many distinguished surgeons have considered this affection worthy of their study, and innumerable plans for its cure have been devised from time to time. Anel, Petit, Wathen, Ware, Scarpa, Dupuytren, Beer, Desault, Travers, Desmarres, Hays, Bowman, Critchett, Weber, Stilling, Noyes, H. W. Williams, John Green, and E. Williams are among those who have suggested methods of treatment, or have modified those previously in vogue. More than a hundred years ago (1781) the plan of introducing a hollow tube of gold or silver into the nasal duct was proposed by Mr. Wathen, in England, and until quite recent times this method, which was revived by Dupuytren, was still practised. The intention was that the tube should remain permanently in the duct, and afford a passageway for the tears. It was introduced through an incision made into the lachrymal sac below the tendon of the orbicularis muscle, and to prevent its falling through the duct it was made flange-shape at the upper extremity. In spite of this, however, the tube usually fell out, sooner or later, generally dropping into the nose, or, if this did not happen, it became obstructed by calcareous matter, so that its usefulness was in a great measure destroyed. The writer has in his possession one of these tubes, made of gold, which was worn for over twenty-five years. During this period the patient was free from inflammation of the lachrymal sac, but was constantly annoyed by epiphora. The tube, which finally fell into the pharynx, was filled

for about one-third of its length with calcareous material. A case has also come under the writer's observation in which a gold tube, after being worn for some time, passed through the alveolar process of the superior maxillary bone, and was finally removed through the socket of one of the incisor teeth which had been extracted some time before.

According to Desmarres, J. L. Petit was the first to attempt the cure of lachrymal stricture by the use of a contrivance intended to be worn temporarily in the nasal duct. His plan was to make an incision into the lachrymal sac, and then to pass a grooved director through the duct, and, by the aid of the latter, to introduce a bougie, which was changed every day. Desmarres himself practised essentially this same method of treatment. Anel attempted to overcome the obstruction of the duct by forcing water into the lachrymal sac, through the canaliculus, by means of the syringe which bears his name. He also endeavored to dilate the strictures by means of slender probes, which he introduced through the canaliculus; but he admitted that the latter method was applicable only to cases of slight obstruction. Benjamin Travers, who was very sceptical as to the utility of the gold cannula which Dupuytren used so extensively, also made use of probes, which he passed through the nasal duct by way of the punctum and canaliculus. His probes were larger than those of Anel, and his results, therefore, were more satisfactory. Dr. Isaac Hays, in this country, early adopted this plan of treatment, and modified and improved the probes of Travers. The probes which he used varied in size from 0.8 to 1.5 mm. in diameter. Ware suggested the use of nail-headed styles, which were to be worn temporarily, with the expectation of curing the stricture. They were introduced through an incision in the lachrymal sac, the round flat head of the style being permitted to remain outside the opening. Beer employed catgut cords of different sizes, which he introduced in a similar way and passed slowly through the duct, a fresh portion of the cord (which was kept coiled upon the head) being drawn into the duct each day, while the part which had been used was pulled out through the nose and cut off. Méjean used meshes of silk threads, which he introduced into the duct through the canaliculus by means of a slender needle-like probe. A more novel idea was that of Blizzard, who filled the lachrymal sac with quicksilver, expecting the obstruction of the duct to be overcome by the weight of the small globule of mercury which the sac is capable of holding. Probes intended to be passed by way of the inferior orifice of the duct, through the nose, were also devised, and great advantages claimed for them, but they were not received with favor.

Coming now to a more recent period, we find a great advance made over all previous methods of dealing with lachrymal obstructions in the operation, devised by Bowman, of slitting the canaliculus, to facilitate the passage of the probes which bear his name. This procedure not only enabled the surgeon to make use of larger probes than had been employed previously, but it facilitated the application of medicinal agents to the lachrymal passages. Still, however, the results obtained by those who followed Bowman's method were far from satisfactory, and relapses after the discontinuance of the treatment were discouragingly frequent. In consequence of this, various modifications of his method were proposed. Mr. Pridgin Teale, of Leeds, and Mr. Critchett, employed probes with bulbous extremities. Dr. E. Williams, of Cincinnati, used similar probes, but with the bulbous portion considerably larger, the largest of his probes at the bulbous extremity having a diameter of 3¼ mm. Dr. H. D. Noyes, of New York, following the example of Dr. E. Williams, insisted upon the necessity of more thorough dilatation of the duct than could be acccomplished by means of Bowman's probes, and probably as early as 1870 (as he informed the writer) made use of short, hard-rubber probes which in their higher numbers had a maximum diameter of 4 mm. He also devised a gouge and a bulbous probe of unusual length, "having a slight bend at the bulb," for the especial purpose of dealing with the very firm strictures which are occasionally encountered at the lower extremity of the duct.[1] Dr. H. W. Williams, of Boston, employed a bulb-pointed, flexible probe, which he claimed could be passed with greater ease through the sinuosities of the contracted duct, while Mr. Crouper, of London, used bougies of laminaria digitata. Dr. Stilling, of Cassel, made a more decided departure, by recommending free incision of the strictures by means of a knife which he devised for the purpose, and which he introduced into the duct through the divided canaliculus.* Dr. Warlmont, who followed Stilling's example, obtained good results, but others were not so fortunate, and this method has never come into general favor. The use of styles of various patterns was also combined with the slitting of the canaliculus. Dr. E. Williams, of Cincinnati, reported favorable results from the use of silver styles, while Dr. John Green, of St. Louis, employed styles made of lead, because they could be easily fashioned to suit the peculiarities of each case, and because they adapted themselves to any irregularities in the shape or curvature of the duct. Instead of the nail-head of the older form of style, all of these, as they were introduced through the slit canaliculus, had curved necks, which were bent over the margin of the lid. Finally, in severe cases which were not relieved by any of these methods of treatment, extirpation of the lachrymal sac (Berlin), or its destruction by means of nitrate of silver (von Graefe), nitric acid (Agnew), chloride-of-zinc paste (Pagenstecher), or the galvano-cautery, was recommended. Removal of the lachrymal gland was also practised, under similar circumstances, by Mr. Zachariah Laurence and others.

In 1877 the writer, having become convinced that success in the treatment of lachrymal strictures was to be found in the use of probes large enough to restore fully the normal calibre of the contracted duct and to obliterate every trace of stricture, determined to ascertain what is the usual size of the healthy nasal duct, and how large a probe might, as a rule, be passed through it. With this end in view, he had a number of large probes made of copper wire, varying in diameter from 3 to 7 mm., and with these he gauged the size of the bony canal of the nasal duct in all the skulls—thirty-nine in number—which were to be found in the Anatomical Museum of the University of Maryland, the method followed being simply to ascertain how large a probe could be passed, without violence, through each duct. In a similar manner a number of canals, with their membranous lining intact, were measured upon the dead subject. The result of these measurements was to make plain, what the writer had been almost convinced of before, that there was a ridiculous contrast between the size of the nasal duct and the size of the lachrymal probes which were commonly employed at that time. For example, while the largest of the six probes originally recommended by Bowman had a diameter of scarcely 1.3 mm., it was found that the smallest ducts in the thirty-seven adult skulls examined (there were only six as small as this) admitted a probe 3 mm. in diameter, and that twenty-three of the seventy ducts which these skulls possessed in a sufficiently perfect condition to be measured admitted probes varying from 4¾ to 7 mm. in diameter, four of them permitting a probe of 5¼ mm. to be passed. The measurements made upon the cadaver were not less striking. Of the twelve ducts examined, one, which seemed to be pathologically contracted, would admit a probe of only 2⅞ mm., but the next smallest admitted one of 3¾ mm., while through three of them a probe 5¼ mm. in diameter was passed without difficulty.† It is true

* It has recently come to the writer's knowledge that, as early as 1846, Dr. Nathan R. Smith, of Baltimore, practised division of lachrymal strictures (probably through an incision made directly into the lachrymal sac), and that he contrived a probe-pointed knife for this purpose. (See Norris and Oliver's "System of Diseases of the Eye," vol. iii., p. 161.)

† The inadequate size of Bowman's probes is made more manifest if, instead of comparing the diameter of his No. 6 with the diameter of the larger probes used by the writer in his investigation, the ratio of

that Bowman's No. 6 was not the largest probe in general use at this time; but few operators had ventured to go beyond a diameter of 2 mm.

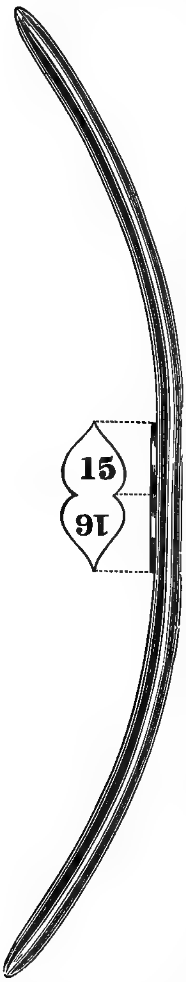

FIG. 3099.—Theobald's Probe for Dilating Strictures of the Lachrymal Duct. (Actual size.)

The writer learned afterward that Dr. H. D. Noyes had previously made an investigation of similar character, and as the result of his measurements had reached the same conclusion which the writer did as to the inadequate size of Bowman's probes and the necessity for employing very much larger ones.*

In consequence of the knowledge gained by his investigation of the normal calibre of the nasal duct, the writer had a series of probes made, comprising sixteen different sizes, the smaller numbers, from 1 to 8, being made of coin-silver; the larger ones, from 9 to 16, of pure silver; No. 1, the smallest, having a diameter of 0.25 mm.; No. 16, the largest, a diameter of 4 mm., with a difference of 0.25 mm. in the diameter of each succeeding number. Subsequently he had the sizes from 7 to 16 made of aluminum because of its lightness and smoothness; he has also had them made of copper, nickel-plated, and has found these very satisfactory, one advantage being that they stand boiling much better than do those made of aluminum. The ends of these probes were fashioned with especial care, being made more conical and pointed than those of Bowman; for it was evident that the larger sizes could not be passed into the sac through the slit canaliculus, if their ends were as square and blunt as they had previously been made. The accompanying illustration, which represents the actual size of No. 16, the largest of the series, shows correctly the shape of the ends and also the curve which has been found most convenient.† The practicability of using the largest of these probes in the treatment of lachrymal strictures was soon demonstrated, and it was not long before the advantage of doing so became manifest. Although satisfied that they were not out of proportion to the actual size of the duct, the writer had at first some misgivings as to the practicability of introducing them into the sac through the divided canaliculus; but he soon found that this was not attended with difficulty.

The writer's experience in the use of these probes now extends over many years, and he is to-day more than ever convinced that it is by such thorough and complete dilatation as they afford that permanent benefit is to be gained in the treatment of lachrymal obstructions. The complete obliteration of all constrictions and the restoration of the normal calibre of the duct are the results which we should aim to accomplish; and to secure this result it is essential that probes as large as those which the writer has recommended should be employed. When smaller ones, of 1.5 or 2 mm. diameter, are used, we merely open a small passageway through the constriction, instead of obliterating it completely, and, as might be expected, a reclosure of this narrow channel is the usual result of a discontinuance of the probing. The large probes, on the other hand, not only open a free passageway through the fibrous and bony obstructions, but, by the pressure which they exert, bring about their absorption, and in this way tend to restore the lining membrane of the duct to its normal state. This change in the condition of the walls of the duct can be detected during the introduction of the probe, and is a matter of frequent observation. The rough, grating sensation which is felt at first from the probe coming in contact with diseased bone gradually disappears, until, after a longer or shorter time, the probe glides smoothly through the duct, giving a sensation not unlike that which attends the introduction of a sound into the healthy urethra.

The writer has never contended that the largest probe of his series can be, or should be, passed through every strictured duct; but his experience has convinced him that the cases in which it cannot be used with advantage are exceptional. The question is frequently asked, Does the use of such very large probes never occasion any mischief? In reply it may be said that the surgeon is less likely to do harm with them than with probes of small size, since the risk of making a false passage is much less. It is undoubtedly true that they frequently leave the previously strictured duct more pervious than the canal usually is in its normal condition; but this causes no inconvenience, beyond the fact that when the nose is blown air is apt to find its way through the duct to the corner of the eye. The impression held by some that the physiological action of the canaliculus and duct in carrying off the tears must be impaired by the use of such large probes, experience has shown to be absolutely groundless. If necessary, it is permissible to use a considerable amount of force in gaining a passage through the duct, and the writer would not be surprised if sometimes he has not only broken through bony strictures, but has "rectified" the boundaries of some physiologically contracted canals. A fracture of these thin plates of bone is, however, a matter of little moment, and less timidity in dealing with these cases should be encouraged.

It will not be out of place, perhaps, to give here a brief description of the method which the writer usually follows in treating strictures of the nasal duct: A few drops of cocaine (4 to 100 solution) or holocaine (1 to 100 solution) are instilled into the inner canthus, and when this has produced its effect a fine probe (No. 1 or No. 2) is introduced into the lower canaliculus, to ascertain whether it is obstructed at any point; for it is not uncommon to find occlusion of the inner end of the canaliculus associated with stricture of the nasal duct; and if this be the case, it is better to make the discovery, and to relieve the obstruction before slitting the canaliculus, otherwise the beak of the knife will fail to enter the sac as it should, and the operation will be imperfectly accomplished. A straight, stiff, rather sharp-pointed probe (Fig. 3100) is the best instrument with which to force this stricture, should one be encountered. It should be passed along the canaliculus to the stricture, and, the lid being kept upon the stretch, should be forced through it with a boring movement. If this cannot be done, a sharp-pointed knife must be used to make an opening into the sac, either before or after the division of

the calibre, or thickness of the former to that of the latter, be stated. For example, if we credit Bowman's No. 6 with a diameter of 1.5 mm., which is larger than it is usually made, we find that a probe 4 mm. in diameter is actually more than seven times as large; while one of 5.25 mm. (which is the size the writer passed through several ducts upon the cadaver) is twelve and a quarter times as large, and one of 7 mm. (the largest introduced into the skulls) is nearly twenty-two times as large.

* Dr. Noyes measured the ducts in five skulls, in some of which sections had been made, so that the size of the lower as well as the upper extremity of the duct could be ascertained. They were all found to be more or less decidedly oval in cross section, with the long axis from before backward, and he measured the long and short axis of each. At the upper end they varied in size from 8 × 6¼ mm. to 5 × 4 mm.; at the lower end, from 7¾ × 5 mm. to 8 × 4 mm. See his paper, already referred to, in the Transactions of the New York State Medical Society for the year 1876. Compare also the measurements of the lachrymal duct made by Mr. Henry Power, and described in "Lectures upon Diseases of the Lachrymal Apparatus," published in the London Lancet, 1886, vol. ii.

† A description of these probes, with an account of the measurements of the nasal duct referred to above, was first published in the Transactions of the Medical and Chirurgical Faculty of Maryland for the year 1877. See, also, "Archives of Ophthalmology," vol. vi., Transactions of the American Ophthalmological Society for the year 1879, and Transactions of the Eighth International Ophthalmological Congress, 1894.

the canaliculus, as the operator may prefer. If, however, no obstruction to the entrance of the small probe into the sac is encountered, Weber's probe-pointed knife is introduced, its blunt end carried well into the sac, and the canaliculus freely divided, care being exercised (as has been previously suggested) to incline its cutting edge somewhat toward the eye, so that the gutter made by the division of the canaliculus shall not present in an outward direction. In performing this operation, as well as in introducing probes into the nasal duct, the writer prefers to stand behind the patient, using his right hand for the right eye, and his left for the left eye. In this position the patient's head can be held firmly by the operator, which is an important consideration, while at the same time it is convenient for his manipulations. Although, formerly, the writer did not feel it incumbent upon him to sterilize the knives and probes used in dealing with lachrymal strictures, an occasional infection from a seemingly clean lachrymal probe has convinced him that only sterile instruments should be used. A brief immersion in boiling water has been found to be the most effective and convenient way of accomplishing the desired result.

FIG. 3100.—Straight, Sharp-pointed Lachrymal Probe. (Actual size.)

The canaliculus having been divided, an attempt is next made to introduce a probe. It is not often practicable to pass into the sac, immediately after dividing the canaliculus, a larger probe than No. 5 of the writer's series, so this is the one usually introduced first; but if No. 6 or No. 7 can be gotten into the sac without difficulty, it is better to start with one of these, since the larger the probe the less the danger of getting out of the right track. It may happen that even No. 5 cannot be made to enter the sac, and then No. 4 or No. 3 must be tried. If, however, there is much difficulty in entering the sac, it is better to wait twenty-four or forty-eight hours before making further attempts, as the changes which take place during this time in the cut edges of the canaliculus frequently enable the operator to introduce easily a probe which at first could not be gotten in at all.

Having succeeded in introducing a No. 5 or No. 6 probe well into the sac, the writer does not hesitate to use such force as may be necessary to carry it, through every obstruction, to the floor of the nose. It is entirely safe to do this, provided the force is exerted in the right direction and we are sure the probe has fairly entered the lachrymal sac. Some nose-bleed, perhaps a little ecchymosis in the region of the lachrymal sac, and a slight temporary increase of the existing inflammation are the only ill consequences likely to ensue. If, during the early stages of the treatment, pain and soreness are complained of, a lotion of acetate of lead and opium or boracic acid and opium is prescribed. The writer, except in dealing with young children, when a few whiffs of chloroform answer a better purpose, always makes several applications of cocaine (4 to 100 solution) or holocaine (1 to 100 solution) to the inner corner of the eye before probing the duct. Although this does not render the operation entirely painless, it makes it much more endurable. He has also thought that he derived benefit from adding cocaine to the vaseline with which the probes are smeared before being passed. This, of course, does not make the introduction of the probe less painful, but it lessens the pain caused by its presence in the duct and by its withdrawal. The length of the interval between the successive probings must be determined, in a great measure, by the sensitiveness of the sac and duct. If the irritation and soreness which the passage of the probe excites are not marked, and subside quickly, which usually happens, the probing should be repeated every other day; but if they are more pronounced, it is better not to repeat it oftener than once in three or four days. It is nearly always practicable, and is certainly desirable, each time that the probe is introduced to increase the size by one number; occasionally a number may be skipped, but this is not often the case. When, on the other hand, a size has been reached that is quite tight, it is best not to go on to the next number until by passing this one several times it has become looser. It is well to allow the probes to remain in the duct for from ten to twenty minutes. As to the size of the largest probe which should be used, it has been stated already that it is not necessary, in every case, to employ one of 4 mm. diameter (No. 16); but, as a rule, it is certainly best to do so, since by such thorough dilatation the cure of the case is hastened, and the danger of relapse greatly lessened. When a case is doing well, and No. 14 or No. 15 is passed with some difficulty, it is not expedient to employ a larger probe; but, on the other hand, if the improvement is not satisfactory, and the lining membrane of the duct gives evidence of still being diseased, the use of a larger probe (though it may be passed at first with some difficulty) is indicated, and will almost certainly be of benefit. After as large a probe has been introduced as seems desirable, the interval between the probings is gradually increased, first to four or five days, then to a week, and then to ten days or a fortnight. Finally, when all evidence of inflammation has disappeared, and the strictures show no tendency to recontraction, a period of a month or six weeks is allowed to intervene, and when two or three such intervals have passed, without any symptoms of a relapse, the probing is discontinued, and the case is dismissed as cured. If the use of the probes is discontinued while there is still a blennorrhœa of the sac or inflammation of the duct walls, a recurrence of the strictures is not improbable.

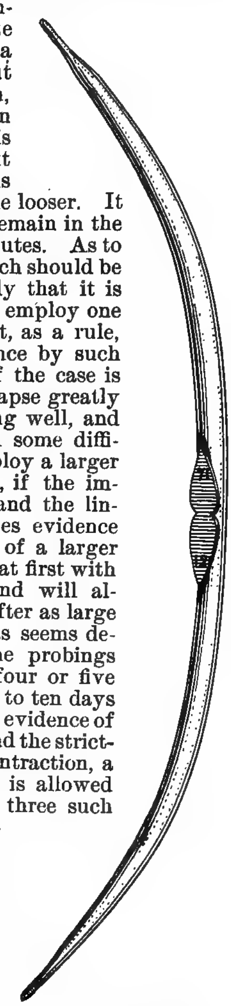

FIG. 3101.—Theobald's Supplementary Probe.

Usually, after these long intervals, it is not difficult to introduce the probe which has been previously passed; but occasionally, owing to a contraction occurring at the point of juncture of the canaliculus and the sac, the probe is arrested at this point and a smaller one has to be substituted. To meet this difficulty, and also, in the early stages of the treatment, to overcome strictures existing at this point which prevent the introduction of probes as large as otherwise might easily be passed, the writer has recently devised the sharp-pointed probe shown in the accompanying illustration * (Fig. 3101). While this probe is manifestly unsuited to probing the duct itself, it has been found most useful for the purpose for which it was intended—the rapid and effectual dilatation of strictures or contractions at the juncture of the canaliculus and the sac. For several millimetres from the tip, as is shown in the illustration, it is quite slender and then dilates rapidly to a much larger size. The slender portion has been made to correspond in size to a No. 3 probe, the larger portions to No. 12 and No. 14, respectively. To effect the requisite dilatation it is necessary to pass it only a short distance into the duct, when it may be with-

* Transactions of the American Ophthalmological Society, 1901; American Journal of Ophthalmology, September, 1901.

drawn and one of the ordinary probes passed to the floor of the nose.

The writer has never thought any of the contrivances for applying astringents, or other medicated solutions, to the sac and duct—such as the syringe of Anel and the more recently-proposed fenestrated hollow probe—of much practical value; but in every case he prescribes an antiseptic or astringent collyrium, which the patient is carefully instructed to drop into the inner corner of the eye, with a pipette, three times a day; and this he regards as an important adjunct to the probing treatment, especially when there is blennorrhœa of the sac (which there usually is during the early part of the treatment) or inflammation of the lining membrane of the duct. Before making this application the patient empties the sac of any tears or mucus which it may contain by pressure with the finger, and then, to facilitate the entrance of the drops into the sac and duct, he is instructed, after having instilled them in the neighborhood of the inner canthus, to look upward and wink the lids. The collyrium which has been found most useful is bichloride of mercury dissolved in normal salt solution (1 to 12,000 to 1 to 8,000); a solution of alum and boracic acid—one or two grains of the former and ten grains of the latter to an ounce—has also given good results. When there is a decidedly purulent discharge from the lachrymal sac a weak solution of protargol (2 to 100 to 4 to 100) will be found efficacious. The use of the collyrium should be kept up, not only throughout the treatment, but for some time after the introduction of the probes has been discontinued. The condition of the nasal mucous membrane should be looked to, and should receive such treatment as may be called for. Constitutional remedies may also be required, tonics and alteratives being useful in some cases, and muriate of ammonia being especially indicated when there is nasal catarrh.

The length of time during which the probing is continued varies greatly in different cases. The strictures yield readily, and the epiphora, the blennorrhœa of the sac, and the inflammation of the lining membrane of the duct disappear quickly in some cases, while in others the improvement is slow. It is never safe to stop the use of the probes altogether, as long as the epiphora persists and there are any traces of inflammation present; but in obstinate cases we may vary the interval between the probings, increasing it considerably at times, for it occasionally happens that the inflammation is kept up by the too frequent use of the probes. To supplement the dilatation effected by the probes the writer has employed electrolysis to a limited exent, but it has not seemed to him that much good was accomplished thereby.

Are the results obtained by this rather tedious, and to the patient somewhat trying, plan of treatment satisfactory? Does it permanently cure a considerable portion of the cases in which it is employed? And is it really an improvement upon the innumerable other methods which have preceded it? The writer's judgment upon these points will, perhaps, hardly be regarded as unbiassed; he has no hesitation, however, in giving an emphatic affirmative reply to each of these interrogatories. If the patient can be kept under the observation of the surgeon, and if, having confidence in him, he is willing to accept his dictum as to the size of the probes to be employed and the duration of the treatment, the cases are extremely few in which an absolute and permanent cure cannot be obtained. The cases which fall by the wayside, the patients who become discouraged when the treatment is but half accomplished and discontinue their visits to the surgeon, are not few; but those who hold out to the end are almost sure to reap their reward by obtaining entire relief from their previous discomforts. The writer does not claim that no failures occur. They do happen in a small minority of cases, even when every detail of the treatment has been carried out. There are two classes of cases in which the treatment is more likely to be unsuccessful: When the stenosis of the duct is dependent upon, and associated with, ozæna or severe nasal catarrh, the strictures show a greater tendency to recur, because, though the canal may have been widely dilated, its lining membrane is not apt to assume a healthy condition so long as there exists pronounced disease in the contiguous lining membrane of the nose. In another class the canaliculi exhibit a persistent inclination to become occluded at their point of juncture with the lachrymal sac, and in consequence of this we not only have the epiphora re-established, but, probably because of the tears not passing through it, the nasal duct itself is apt to become again obstructed.

There are also some sources of failure which, by being kept in mind, may be avoided. For example, the writer has in several instances met with cases that had previously been treated with only partial success, in which there was discovered, close to the lower extremity of the duct, a stricture which there was good reason to believe had never before been penetrated by the probe. Under such circumstances, when the probe was first passed through this stricture to the floor of the nose, the patient at once exclaimed that the sensation produced was a new one, and that the instrument had never before seemed to "go so far down." Of course, such a mistake as this must necessarily render the treatment of no avail. The operator should always bear in mind that in occlusion of the nasal duct multiple stricture is the rule rather than the exception, and that the strictures, which may be circumscribed and annular, or ill-defined and of large extent, are liable to be encountered at any point in the duct from its upper rim to its valve-like lower extremity. When doubt exists as to the probe having reached the floor of the nose, an endeavor should be made to see the tip of the probe by light reflected into the nose or to touch it with a bent probe introduced through the anterior nasal orifice. Another mistake which may be made is in the introduction of the probes into the lachrymal sac. At the outset of the treatment, especially, there is at times considerable difficulty in accomplishing this owing to the existence of a constriction at the juncture of the canaliculus and the sac, and if, by mistake, the probe is turned up and forced down into the nasal duct before its point has fairly entered the sac, a false passage will be made directly from the canaliculus into the duct. If the probes are afterward passed through this false channel, the probabilities are that the natural channel into the sac will after a time become closed, and, as the false passage is very apt to share the same fate ultimately, it is evident that the treatment will come to naught.

During an attack of acute inflammation of the lachrymal sac it is never prudent to attempt the introduction of probes. It will be time to begin this after the acute symptoms have been completely relieved by the means which have been already described. The writer has not found it necessary to resort to any special measures to promote the closure of lachrymal fistulæ, except, perhaps, to touch exuberant granulations, if they are present, with a crayon of nitrate of silver or a crystal of sulphate of copper. He has always found that, as the condition of the lachrymal sac and the duct improve under the use of probes and antiseptic collyria, the fistulæ heal without difficulty.

Blennorrhœa of the lachrymal sac, with or without epiphora, is occasionally met with in infants. Operative treatment is only exceptionally called for in these cases; but if the antiseptic collyria which have been mentioned fail to relieve the condition after having been tried perseveringly, the canaliculus should be divided and probes be introduced. The outcome of this treatment is usually very satisfactory, and to effect a cure it is seldom necessary to repeat the probing oftener than four or five times.

The possibility of mistaking tumors lying in the region of the lachrymal sac, or extra-cystic abscesses, for distention of the sac should be borne in mind. The writer has once or twice seen cysts in this region which in appearance closely resembled "mucocele."

At one time the writer used quite extensively the leaden styles of Dr. John Green; but the results obtained from them were not encouraging, and for some years he has not employed them. Although they usually afford

relief while they are in the duct, a return of the former symptoms is very apt to follow their withdrawal. As a substitute for the probe in cases which can remain but a short time under the surgeon's care, they, or styles made of aluminum, may be used. Under such circumstances, however, the writer not infrequently has found it practicable to teach patients to probe their own lachrymal ducts; and for this purpose he has devised the probe shown in Fig. 3102. After the duct has been well dilated by the passage several times of one of the larger probes, it is not difficult for the patient to introduce a probe of this pattern, usually No. 13 or No. 14. With a probe of this size there is practically no danger of making a false passage, and the previous instillation of a few drops of cocaine renders the procedure almost painless. In this way relapses, liable to follow a too early discontinuance of the probing, are obviated and the permanency of the cure is assured.

FIG. 3102.—Modified Form of Lachrymal Probe to be Used by Patients. (Actual size.)

It only remains to be said that the writer has been so well satisfied with the results which he has obtained in the treatment of nasal-duct strictures by the thorough dilatation plan which he pursues that he has not been tempted to make trial of the treatment by division recommended by Stilling. He can scarcely persuade himself, however, that permanent benefit would often result from this operation, unless it were followed by systematic and thorough dilatation. The operations of destruction of the lachrymal sac and extirpation of the lachrymal gland, which have been referred to as measures recommended in intractable cases of obstructive lachrymal disease, are also procedures which he has never resorted to. There may be cases, perhaps, in which it is proper to employ these extreme measures, but he has not encountered them and he believes they are of very rare occurrence.

Samuel Theobald.

[1] Transactions of the Medical Society of the State of New York for the year 1876, p. 150.

LACTANIN—Bismuth di-lacto-mono-tannate—is a bismuth compound of lactic and tannic acids which occurs as an odorless, tasteless, yellow powder insoluble in water. For the diarrhœa of infants, or in tuberculous or simple enteritis, Moncorvo uses it in some such combination as: ℞ Lactanin, gr. xxiv.–xxxvi. (1.6–2.4 gm.), syrupi acaciæ, ℥ i. (30 c.c.). M. Sig.. One teaspoonful three to five times a day. *W. A. Bastedo.*

LACTATION. See *Breast*, *Female*, and *Galactagogues*.

LACTEALS. See *Lymphatics*.

LACTIC ACID.—Of the isomeric bodies known chemically by the generic name of *lactic acid*, the common acid, called technically *isolactic* acid, is the one used in medicine. This body is a product of a certain form of fermentation of sugar, a fermentation that occurs very readily in the case of milk. Hence the name and the common source of this acid. Lactic acid is official in the United States Pharmacopœia under the title *Acidum Lacticum*, Lactic Acid, and is required to be of a strength equal to seventy-five per cent. of absolute lactic acid ($HC_3H_5O_3$). Lactic acid is a syrupy liquid, colorless and odorless, but sharply sour to the taste. It mixes freely with water, alcohol, and ether, is hygroscopic, and should be kept in well-stoppered bottles. The specific gravity of the official acid is about 1.213 at 15° C.

Although strongly acid, lactic acid is neither corrosive nor poisonous. It is contained, normally, in gastric juice, and accordingly is suggested as an adjuvant to pepsin in atonic dyspepsia. From theoretical considerations it was at one time expected to prove hypnotic, but it has not justified the expectation. Also it was vaunted as an antidiabetic medicine, but again has failed of success. The only really notable properties of the acid are that it dissolves to a considerable extent freshly precipitated calcium phosphate, and hence is useful in the preparation of the so-called *syrup of lactophosphate of calcium;* and that it dissolves false membranes, and so may be employed locally in diphtheria and croup. In the latter application the acid may be used by spraying or gargling, in admixture with water, of a strength of from four to twenty per cent. Lactic acid may be administered internally in teaspoonful quantities or more, well diluted with sweetened water. *Edward Curtis.*

LACTOL, lacto-naphtol, a lactic acid ester of beta-naphtol, is a tasteless substance which, splitting into its components in the intestine, acts as an intestinal antiseptic. Its dose is 0.25–0.5 gm. (gr. iv.–viij.).

W. A. Bastedo.

LACTOPHENIN, lactyl para-phenetidin ($C_6H_4.OC_2H_5.NH.C_3H_5O_2$), is produced by the action of lactic acid on phenetidin in the presence of dehydrating agents. From phenacetin it differs only in the substitution of a lactyl group ($C_3H_5O_2$) for the acetyl group (CH_3CO). It occurs as a white crystalline powder without odor and with a bitterish taste, is split into its components by acids and alkalies, and is soluble in 300 parts of water (some authorities say 500 parts) at 15° C., in 55 parts of boiling water, and in 8.5 parts of alcohol. It is eliminated in the urine as paramido-phenol, which gives a deep red color with ferric chloride.

Physiologically, it does not differ essentially from phenacetin, except that its sedative and hypnotic tendency is greater. As an antipyretic, it reduces temperature rapidly and without much depression, though sweating may occur. Untoward effects following a dose of eleven grains were: prickly heat, erythema, and swelling of lips, tongue, and vagina. Witthauer reports four cases of catarrhal jaundice, and Wenzel one case of jaundice with clay-colored stools following fourteen grains. Kronig has recorded a case of cyanosis and death, though the amount of drug taken is not stated. Experimentally Strauss produced hemorrhagic erosions in the gastric mucous membrane of a rabbit, and in another congestion and profuse secretion of mucus in both stomach and duodenum.

There is abundant clinical evidence that lactophenin is a valuable antipyretic and analgesic. Franz Riedl, from a careful study in a large number of cases, came to the conclusion that it is a specific for acute articular rheumatism, is antipyretic but not at all a specific for typhoid fever, and has no influence on the intensity or duration of sepsis, pneumonia, or erysipelas. Clevenger finds it analgesic in various acute pains such as toothache from alveolar abscess, but declares it useless in the shooting pains of locomotor ataxia, the pains of syphilis of the cord, and those associated with cancer. Von Jaksch, Martin, Jacquet, Caillé, and many others have used it with good results in various febrile conditions, rheumatism, colic, the pains accompanying the onset of acute fevers, neuralgia, and as a sedative in restless and nervous conditions. Cristiani gave it in over two hundred cases of insomnia in the insane, and from this experience concluded that it was capable of inducing quiet, deep sleep for from four to nine hours. Combined with the extracts of belladonna and stramonium, Martin employs it for ovarian neuralgia. A mixture of caffeine gr. ij. (0.13 gm.), quinine hydrobromate gr. iij. (0.2 gm.) and lactophenin gr. vi. (0.4 gm.), makes an excellent capsule for migraine. The dose is gr. iij. to viij., or even gr. xv. (0.2–0.5–1.0 gm.) for an adult, given dry on the tongue, suspended in syrup, or in capsule or cachet. The dose for a child is gr. ss. to gr. ij. (0.03–0.13 gm.), and several writers speak of its apparent safety for children. *W. A. Bastedo.*

LACTUCARIUM.—"The concrete milk juice of *Lactuca virosa* L. (fam. *Compositæ*)" (U. S. P.). Although thus defined, the product is actually obtained from several species of the genus. The one specified is native of Central and Southern Europe and is also cultivated for the sake of the lactucarium. It is a coarse, narcotic-smelling, and bitter-tasting biennial herb, with an upright, prickly, paniculately branching stem a metre or more in height, and long, spreading, ovate or oblong, sinuate-dentate, pointed, and prickly leaves, and flowers similar to those of the common garden lettuce.

The herb itself has been official in the British Pharmacopœia, but is no longer so. *L. altissima* Bieb, of the Caucasus, is a gigantic species cultivated in France for the production of a French variety of lactucarium. *L. scariola* L., another prickly European species, is also said to yield a portion of the drug, as well as *L. sativa* Linn., the common salad or garden lettuce. The American species, *L. canadensis* L., has also been experimented with; it yields a lactucarium of but little bitterness and of inferior quality.

Lactucarium, in its present form, was introduced by Dr. Coxe, of Philadelphia, who collected it from garden lettuce at the end of the last century. Lettuce itself, as a medicine, is of much older date, and garden lettuce, as a salad, has been cultivated for several hundred years.

Collection.—After the plants have sent up flowering stems, they are cut off about a foot from the top, when the "milk" flows out freely; this is wiped off with the finger and conveyed to a little cup; the operation being continued with successive stems until the cup is sufficiently filled. Fresh slices are cut off and fresh collections made daily, throughout the season. As first exuded, it is liquid and pure white, but it soon sets upon exposure, and turns yellow and then brown. When it has coagulated, it is emptied from the collecting vessel and dried by gentle heat. The form of lactucarium varies with the details of its collection. French samples are in small circular cakes, the English (Scotch) is in broken fragments, and the German, which comprises most of that imported here, evidently consists of quarters of a plano-convex cake cut up before it is quite hard. It is, however, brittle, and often much broken.

Description.—Lactucarium is a brittle, structureless solid, of a gray or dull red-brown color, whitish or yellowish within, as shown by fresh fracture, of a waxy lustre when freshly cut, heavy narcotic odor, and disagreeable bitter taste. It is a composite substance, and not wholly soluble in any one menstruum. Alcohol and ether dissolve portions of it; boiled with water, it forms a turbid mixture.

Composition.—The most abundant ingredient, constituting nearly half of it, is *lactucerin*, or *lactucon*, a wax-like substance, common to other milky juices. *Lactucin* is, however, its active principle. This crystallizes in pearly scales; is soluble in boiling water, cold alcohol, and acetic acid, but not in ether, and is very bitter. Yield, 0.3 per cent. *Lactucic acid* and *lactucopicrin* are other constituents. Besides these, *lactucarium* contains vegetable tissue, caoutchouc, gum, cellular tissue, and other vegetable substances, but no starch.

Action and Use.—Common lettuce is well known to be slightly soporific; its effects are occasionally quite marked. The various extracts of lettuce are also more or less so. These apparently contain a trace of hyoscyamine, but it is doubtful if this gets into the lactucarium. Lactucarium has so far shown itself to be an uncertain medicine, often of no value, but, when good, an efficient and pleasant hypnotic; its power of overcoming pain is slight when compared with opium—in fact, almost none, —but simple discomfort or moderate distress is occasionally relieved by it. In cardiac asthma and restlessness it is frequently useful, and it may be tried in numerous cases in which opium is indicated but not well borne. It is free from the subsequent constipation and headache of opium.

Administration.—The uncertain quality of this drug makes its dose a tentative one, but 0.5 gm. or 1 gm. (gr. viij. ad xv.) should show some effect. It may be given in powder or pill, or the fifty-per-cent. official tincture. From the extract, a syrup (*Syrupus Lactucarii*, of ten-per-cent. strength of the tincture, five per cent. of lactucarium) is made; a useful vehicle and adjuvant for opium or other hypnotics. *W. P. Bolles.*

LADANUM.—Labdanum. A resin collected in Greece and the Grecian Islands from several species of Rock Rose (*Cistus Creticus* Linn., *C. ladaniferus* Linn., *C. Cyprius* Lam., etc.; Fam. *Cistaceæ*), whose stems and branches abound in a sticky exudation. Two methods, both coarse and dirty, are in vogue for collecting it. The first is to whip or rake the bushes by an instrument having a number of leather thongs at the end, to which the resin sticks, and from which it is scraped off; the second, and more common, has been in use for many centuries, viz., to comb and press it out from the beards and wool of goats and sheep which pasture among it. It is then melted and manipulated, and often adulterated with other resins, or mixed with sand, etc., perhaps as much to give it solidity as for falsification. Common Ladanum is imported in snake- or worm-like coils; it is a dark gray or greenish-gray brittle solid, of resinous odor and a bitter balsamic taste. It consists of from twenty to eighty per cent. of *resin*, a small amount of *oil*, *gum*, and other vegetable products, and the rest of dirt, sand, or other foreign admixture.

Action and Use.—The same as those of other resins. As a medicine it is obsolete; plasters, fumigations, etc., sometimes contain it. *W. P. Bolles.*

LAKE PARK WHITE SULPHUR SPRINGS.—Vernon County, Missouri.

Post-Office.—Nevada. Hotels.

Nevada is a flourishing and beautiful little city, located in western Missouri, one hundred miles south of Kansas City. It is accessible by three railroads, viz., the Missouri, Kansas and Texas, the Missouri Pacific, and the Nevada and Minden Railroad. Lake Park, in which the springs are located, is an attractive spot one mile out from the city, and reached by horse-cars, which run every twenty minutes. The three principal springs are known as the "White Sulphur," the "Iron," and the "Clear Water" springs. No analysis seems to have been made, but the springs are beginning to attract considerable attention on account of their medicinal properties. The park is about one hundred and thirty acres in extent, and, besides the springs, contains two lakes which afford abundant opportunities for boating, bathing, fishing, etc. *James K. Crook.*

LAKE TAHOE, or **CARNELIAN HOT SPRINGS.**—Placer County, California.

Location.—These hot and cold mineral springs are located on Carnelian Bay, at the northern end of Lake Tahoe. They form part of the attractions of this famous inland sea. They are reached by rail to Truckee, and from thence by stage over a good mountain road in about two and one-half hours' drive. The scenery en route is grand. The Truckee River is crossed and recrossed, mountainsides and heights are scaled, and fertile valleys, on which graze immense herds of cattle, are traversed. Forests of beautiful pine and cedar rear themselves at intervals, humming sawmills fill the air with life, and wild, romantic views greet the eye at every turn. Lake Tahoe is a noble sheet of water, having an altitude of 6,202 feet above the sea level. It is divided by the California and Nevada State line, has a length of 21 miles, a width of 12 miles, and is 1,645 feet in depth. The appointments at the springs resort are very complete. Excellent bathing facilities have been provided, where all kinds of cold or hot sulphur baths may be taken. The springs are about fifty in number, and are well kept and cared for. The waters are sulphurous and saline, and a few are carbonated. They contain sodium chloride, calcium sulphate, silica, organic matter, magnesium sulphate, and free sulphureted hydrogen gas.

The baths are used with success in rheumatic and gouty troubles and the waters are taken internally for liver and kidney disorders, chronic constipation, and cutaneous diseases. The high altitude and invigorating mountain air recommend the location as a resort for broncho-pulmonary affections. There are excellent facilities for camping, hunting, and fishing in the vicinity.

James K. Crook.

LAKE VIEW HOT SPRINGS.—Lake County, Oregon.

POST-OFFICE.—Lake View. Hotels in the town.

ACCESS.—Viâ Southern Pacific Railroad to Ager, Cal., and thence by stage. The springs are located one mile and a half south of Lake View, and four miles northeast of Goose Lake, one of the largest bodies of fresh water in the West (50 miles in length, with an average breadth of 15 miles). The elevation is about 5,000 feet above the sea level, and the surrounding country of a mountainous character. The climatic conditions are very favorable. We are informed that the water has a temperature of 164° F., and flows at the rate of about 500 gallons per hour. A partial analysis by Dr. Parnell, post surgeon at Camp Warner, Ore., in 1869, showed the presence of iron, soda, sulphur, magnesia, and other mineral ingredients. The water is said to be beneficial in numerous complaints, especially rheumatism. The attractions at this place afford excellent inducements for the establishment of a first-class health resort.

James K. Crook.

LAKEWOOD.—The village of Lakewood, formerly known as Bricksburg, and situated in Brick Township, Ocean County, N. J., has attained a world-wide reputation as a winter resort for pleasure and health; and among the physicians of this country it is widely known as a place where the climatic conditions influence most favorably, during the winter and early spring seasons, those people who go there while convalescing from disease, whether acute or chronic.

Reference to the large geological map of New Jersey, accompanying the report of the State Geologist for the year 1881, shows that the village is situated forty-four miles south by west from New York City, nine miles back from the Atlantic coast-line on Squan Beach, and five miles back from the mainland shore of Barnegat Bay; and that it stands upon a tongue of sandy "pine-land" soil which runs back from the latter to a point some two and a half miles beyond Lakewood, has at Lakewood a breadth of a mile and a half, and is inserted, wedge-fashion, between two portions of an extensive "oak-land" district. Both the "pine-land" and the "oak-land" soils are sandy; the "pine-land" being especially so. The geological map just referred to shows us a very large extent of country, triangular in shape, which reaches from the Atlantic coast at Long Branch (twenty miles northeast of Lakewood) almost to the very shores of Delaware Bay, having an extreme length of about ninety miles and an extreme breadth of about forty-five miles. This area is made up exclusively of "oak-lands" and of "pine-lands," in the proportion of about two parts of the former to one part of the latter. The greater portion of the "pine-land" or "pine-barren" soil is to be found in the northern half of this great triangle; so that for this half the relative proportions of "oak-land" and of "pine-land" soils are exactly the reverse of those just stated—that is, the very sandy "pine-lands" are, throughout this northern half, twice as great in area as are the less sandy "oak-lands." It has already been stated that the village of Lakewood is built upon pure "pine-barren" soil, but the "oak-land" predominates over the "pine-land" in the immediately surrounding country. Nevertheless, by far the most extensive region of unbroken "pine-barren" country to be found in the State, comprising an area which may be roughly estimated at no less than four hundred square miles, lies to the southward of Lakewood, and at a distance from the village of less than twenty miles; while the intervening "oak-land" region is intersected by tongues of "pine-land" similar to the one upon which Lakewood itself stands, but of decidedly greater area than this one. Other strips of "pine-land" country are dove-tailed into the "oak-land" region to the northward. From this account of the geology of the New Jersey southern interior it must be evident to the reader that the soil, for many miles about Lakewood, is of an exceptionally sandy and dry nature.

Its distance back from the coast excludes Lakewood from the category of seaside stations; for, in Professor Smock's appendix to the "Report of the State Geologist of New Jersey" (1881), we read that "the influence of the ocean's waters is felt very decidedly to a distance of four to eight miles from the line of beach or outer coast-line, from Sandy Hook to Cape May," and that the climatic limit of the Atlantic coast belt in Monmouth County "is thought to be four or five miles; in Ocean County" (the county in which Lakewood is situated) "it follows closely the line of clearings or settlements, not going beyond the line of woods or into the forest belt. It is here from four to seven miles wide." *

Of the 3,234 square miles of forest area in the State of New Jersey, Ocean County contains 313,087 acres of forest land; to this and the prevalence of the pine in great abundance in this vicinity the salubrity of the place is greatly due. For decades past the balsam-laden air of pine-woods regions like Aiken, S. C., and Arcachon, France, has been looked upon by physicians as particularly beneficial for their convalescent patients, and Lakewood, which bears such a close resemblance to the former place, owes its reputation primarily to the beneficial influences of the climate upon invalids of various types—not merely those with pulmonary complaints, but that far more numerous class of neurasthenics and convalescents from all acute diseases. In localities where the pines grow a sandy soil may always be looked for. Borings from the many artesian wells in the village proper show strata of almost pure sand down to a depth of six hundred feet below the surface. Consequently the dryness of the soil is one of the most noticeable features of this region. Fogs are rarely seen, and the relative humidity is always low. Government meteorological records for Lakewood are unfortunately wanting. However, the actual thermometric readings for New York and Lakewood will be found to differ to only a slight extent, but the greater dryness of the atmosphere in the latter region conveys the impression that its temperature is noticeably higher than that of New York. At times there are very high winds, and, were it not for the protection afforded by the forests, walking and driving would on such occasions be very unpleasant. Rains occur with about the same frequency as along this section of the New Jersey coast. During recent winters snow has covered the ground for only short periods of time; sleighing can rarely be enjoyed for one week's time, and occasionally an entire winter may pass without any sleighing. There is one peculiarity of the climate which deserves notice. I refer to the fact that a marked lowering of the temperature takes place at sunset and is associated with considerable dampness of the atmosphere. These conditions last for only two or three hours. During the winter months, therefore, invalids should be within doors by sundown.

Originally intended for a health resort Lakewood has rapidly outgrown the dreams of its promoters and has developed into one of this country's most noted winter pleasure and residential resorts. Its population is now 3,200, and it is capable of caring for more than 2,500 transient guests in its hotels and numerous boarding-houses. Luxurious accommodations and an excellent cuisine are afforded by the leading hotels, while for those who prefer a quieter and less expensive mode of life there are many pleasant boarding-houses. The majority of both the hotels and the boarding-houses now decline to accept as guests those who are suffering from pulmonary tuberculosis. Quite recently one of the larger hotels

* These two paragraphs are from Dr. Huntington Richards' article on Lakewood in the former edition of the HANDBOOK.

has increased its attractiveness and usefulness by installing a complete plant for hydrotherapy.

The season begins on October 1st of each year, and by the middle of November all the hotels are open and the cottages full. Daily morning and evening concerts are given at the hotels. The walks around the lake and into the woods are kept in the best condition possible; even after a heavy rain the soil absorbs the water so rapidly that in the course of a few hours it is possible to walk out without getting one's feet wet or muddy. Well kept roads foster the spirit of outdoor life and driving, bicycling, and automobiling are thereby made more enjoyable. Bridle paths add to the charms of the more vigorous horseback exercise, and cross-country riding may be watched at stated intervals each season. Polo games and tournaments prove the most attractive feature of the season and may be witnessed every spring and autumn on one of the finest polo fields in this country. A speedway, one mile and a quarter in length, brings many a gentleman with his trotting horses to the village. Then, besides, there are a country club, a golf club, and facilities for boating on the lake, for bowling, and for lawn-tennis. There is an abundant water supply, chiefly from artesian wells, and the sewers empty into a rapidly flowing stream at some distance outside the village proper.

Lakewood to-day offers every inducement and advantage to parents who wish to bring their children up in the country. There is no lack of schools and churches.

Lakewood is one hour and thirty-five minutes from New York City by rail, and two hours from Philadelphia.

Irwin Howell Hance.

LAMINARIA.—The prepared stipes of *Laminaria digitata* Lam. (fam. *Fucaceæ*). This species is a large, foliaceous, olive seaweed, which from a branching and stout foot ("root") sends up a long, terete, strong stem, surmounted by a flat, leaf-like, lanceolate, oval or more or less divided and crispy-margined thallus. It attains a great size, often measuring six or eight metres long, with a blade one metre or more in breadth. Laminaria is not used in medicine, but its cylindrical, and, when dry, horn-like stipes are cut and filed into suitable shapes for tents, for dilating the os uteri and sinuses, which they do by their capacity of swelling exceedingly when soaked in watery fluids. These tents are generally cut in cylinders from 3 to 8 mm. ($\frac{1}{8}$ to $\frac{1}{3}$ inch) in diameter and from 25 to 50 mm. (1 to 2 in.) in length; they are filed and sand-papered smooth, and the ends are carefully rounded. A hole made in one extremity holds the loop of silk for removing it. Its swelling capacity is developed in three or four hours, and often enlarges the tent to two or three times its original diameter. It was introduced into medical use but a few years ago, as a substitute for the sponge tents, which had in a number of instances already shown how apt they were to hold or develop infectious material, and cause chills, septicæmia, and even death. Laminaria, in consequence of its close texture, presents no apertures in which such material could be permanently held, and practice has shown it to be much safer.

W. P. Bolles.

LANE MINERAL SPRINGS.—Calaveras County, California. These springs lie thirty-five miles east of Stockton. They are 1,000 feet above the sea level, and are surrounded by hills and valleys clad in forests of pine. The main spring flows from 50 to 75 gallons per hour. The following probably incorrectly reported analysis is said to have been made by the San Francisco Refining and Analytical Association:

LANE MINERAL SPRINGS.

ONE UNITED STATES GALLON CONTAINS:

Solids.	Grains.
Iron carbonate	122.00
Magnesium carbonate	38.51
Epsom carbonate (?)	29.76
Alumina	2.01
Sodium carbonate	8.52
Free sulphuric acid	15.24
Silica	15.20
Potassium carbonate	18.01
Organic matter	2.72
Total solids	251.97

Free sulphureted hydrogen gas, 105 cubic inches.

This water has been in use for several years, and is said to be beneficial in constipation, dyspepsia, chronic malarial poisoning, and in kidney and liver complaints.

James K. Crook.

LANOFORM. See *Formaldehyde.*

LANOLIN.—Under the title of *lanolin*, Oscar Liebreich proposed, to serve as a basis for ointments, the peculiar body that results from the mixture of a *cholesterin* fat with water. The cholesterin fats are peculiar, in comparison with ordinary glycerin fats, in not decomposing, in "taking up" and holding in intimate blending an equal quantity of water, in mixing also with glycerin, and in possessing a high diffusion power. By reason of the latter power, lanolin used as an inunction ointment is supposed rapidly to impress the system with any absorbable active drug substance that may be incorporated with it. Lanolin is obtained from the natural fat of sheep's wool, and such fat, purified and mixed with not more than thirty per cent. of water, is official in the United States Pharmacopœia under the title *Adeps Lanæ Hydrosus*, Hydrous Wool-fat. This wool-fat, or lanolin, as it is still commonly called, is a yellowish-white material of ointment-like quality and a faint characteristic odor. It is insoluble in water, but yet will mix with twice its weight of water and still retain its unctuous quality. It melts at about 40° C. (104° F.). It is somewhat sticky, but this quality can be removed by the addition of from twenty to twenty-five per cent. of some ordinary oil, such as castor oil, or of vaseline.

Clinical experience with lanolin does not seem fully to realize the expectation of unusual power on the part of the substance to penetrate the skin, on inunction. Nevertheless, lanolin makes a very serviceable material for inunction purposes, either by itself or medicated.

Edward Curtis.

LAPPA. See *Burdock.*

LARCH BARK.—The bark of the trunk and branches of the European Larch, *Larix europœa* D. C. (fam. *Coniferæ*), was formerly largely used for its rather mild terebinthinate and astringent properties, and was at one time official in the British Pharmacopœia. It has now almost disappeared from the Materia Medica, in favor of the more definite products of that family.

It contains *volatile oil*, *resin*, a peculiar *tannin*, and *larixinic acid*. The turpentine and tannin make larch and other fir barks astringent and stimulating to the renal and bronchial mucous membranes. It is used to a slight and diminishing extent in bronchitis, vesical and urethral catarrh, as well as in purpura and other hemorrhages. A tincture (two and a half ounces to the pint) is an eligible form. Dose, 1 or 2 c.c. (♏ xv. ad xxx.), several times a day.

Henry H. Rusby.

LARD.—ADEPS. "The prepared internal fat of the abdomen of *Sus scrofa* L. (order *Pachydermata*), purified by washing with water, melting and straining" (U. S. P.).

The tissue from which lard is obtained, lying at each side of the backbone and enclosing the kidneys, and which goes by the name of "leaf lard," is washed, chopped, cleaned from connective bands and trabeculæ, and then, with a little water, exposed to a boiling temperature until the connective tissue is softened and the fat has run out; it is then strained, and the heat continued until the water is nearly removed and the melted fat is clear and homogeneous, when it is poured out and cooled. If a very fine product is desired, it should be filtered in a hot filtering apparatus.

Lard should be of a soft solid consistency, white, unctuous, with a faint but not at all rancid odor, and a bland taste. Its specific gravity is about 0.932 and it melts at 38° to 40° C. (100.4° to 104° F.). It is insoluble in water and very little soluble in alcohol.

Olein, palmitin, and stearin are the principal constituents of lard, their relative proportions (upon which its consistency depends) varying considerably.

Commercial lard is so universally impure, either being mixed with water or salt, or having a portion of its liquid oil removed, that it is in general unfit for medicinal use, and the apothecary will do well always to prepare his own. Tens of thousands of barrels of cotton-seed oil are annually used in this country for the manufacture of artificial lard.

Ordinary lard rather rapidly becomes rancid and irritating, but if perfectly pure and free from water it will keep, in a cool place, for a very long time. When it is to be used during warm weather, five per cent. of it, or more if necessary, should be replaced with white wax. For pharmaceutical purposes it is scented, as well as preserved, with benzoin, a little of the balsam being tied in a bag and suspended in the melted lard for two hours. Thus treated, it is almost entirely permanent, besides having an agreeable odor.

Lard is an article of food, and is emulsified, like other fats, when taken into the intestines, without any particular physiological action. As an external dressing, it is protective and bland in a high degree, qualities which have given it its popularity as a basis of ointments and cerates. Those of the United States Pharmacopœia follow: A. Benzoinatus, just mentioned, Ceratum, Ceratum Cantharidis, Ceratum Extracti Cantharidis, C. Resinæ, Unguentum, Ung. Hydrargyri, Ung. Mezerei, Ung. Iodi, etc.

W. P. Bolles.

LARDACEOUS DEGENERATION. See *Amyloid.*

LARYNGISMUS STRIDULUS. See *Croup.*

LARYNX, ANATOMY OF THE.—The larynx, which is the principal organ of phonation as well as the guardian against the entrance of foreign bodies into the trachea and bronchial tubes, is situated at the upper and fore part of the neck. Until puberty it is small and presents a rounded form in front. At about this time in the male there are marked and rapid changes. It becomes nearly double in size and the thyroid produces a prominent ridge in front, called the Adam's apple.

The larynx lies between the base of the tongue and the hyoid bone above and the beginning of the trachea below, and, when at rest, in the adult, is in front of the fourth, fifth, and sixth cervical vertebræ, from which it is separated by the lower portion of the pharynx and the prevertebral muscles. In front, it is covered near the median line by the skin and cervical fascia. On either side there are also the sterno-hyoid, the sterno-thyroid, and the thyro-hyoid muscles with the upper portion of the lateral lobe of the thyroid gland and a portion of the inferior pharyngeal constrictor. Farther back and on the side are the large cervical vessels. At the upper part the larynx is triangular in shape with the apex pointing at the anterior median line, but it approaches the shape of a cylinder and is much smaller below, where it joins the trachea. The hyoid bone, the thyroid and cricoid cartilages, the thyro-hyoid membrane, and the crico-thyroid membrane are easily located and are important landmarks.

THE INTERIOR OF THE LARYNX.—The first portion of the larynx we see when looking from above is the epiglottis situated at the base of the tongue. This varies greatly in shape, size, and position. Its crest may present itself as the arc of a small or a comparatively large circle. It is usually situated in the median line, and is commonly but not always symmetrical; it swings up and down over the superior aperture of the larynx, so that it may be found in any position from the vertical to the horizontal. Immediately below the crest of the epiglottis, is a rounded prominence, the cushion produced by a prominence of the petiolus together with some fatty and adenoid tissue. The mucous membrane covering the epiglottis is of a yellowish pink color and is more adherent to the posterior surface, in which open the mouths of a number of glands. From both sides of the epiglottis there extend toward the arytenoids, at the posterior portion of the larynx, two folds of mucous membrane, the aryteno-epiglottidean folds, which contain some ligamentous and muscular fibres as well as the cuneiform cartilages. These cartilages show as a whitish nodule in front of the prominence produced by the arytenoid and Santorini's cartilages on either side. At the posterior portion of the larynx, between the arytenoid cartilages, is a space called the interarytenoid space. This is quite extensive during respiration but is much shorter during phonation. Just below the apex of the arytenoids and extending from the front of these to the angle of the thyroid cartilage, below the attachment of the epiglottis, are two folds of mucous membrane enclosing delicate fibrous bands, the superior thyro-arytenoid ligaments. These folds are called the ventricular bands and form the upper boundary of a space, the ventricle of the larynx, which extends under and between them and the alæ of the thyroid cartilage, and then terminates anteriorly in a pouch, the sacculus laryngis. This pouch contains many mucous glands which by their secretion moisten the vocal cords. Just below and parallel with the ventricular bands are two white bands, the *true vocal cords.* They appear to be a part of the ventricular bands, but are at a lower level and are separated from them by the ventricles. They are composed of yellow fibrous tissue covered by a very thin and closely adherent mucous membrane. A cross section shows the vocal cord to be a triangular prism with the base outward and attached throughout its whole extent to fibres of the thyro-arytenoid muscle. Anteriorly the cord is attached to the receding angle of the thyroid cartilage just below the ventricular band and within the insertion of the thyro-arytenoid muscle. Posteriorly there are three sets of fibres; one is attached to the vocal process of the arytenoid cartilage, another to its anterior surface, and the third to the crico-arytenoid capsular ligament. At their posterior attachment there is often seen a slight depression of a pearly white color; this is the tip of the vocal process of the arytenoid cartilage. There is an open triangular space between the vocal cords—the *glottis* or *rima glottidis.* This varies in extent according to sex and age, being about seven-eighths of an inch long in the adult male and about five-eighths of an inch in the female. The width constantly varies as the cords are approximated or separated, and in

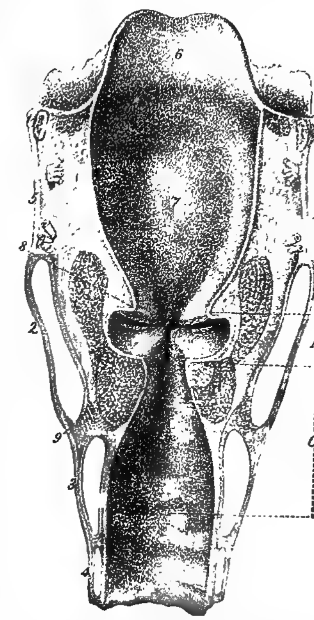

FIG. 3103.—Frontal Section of an Undissected Larynx. The three divisions of the larynx are marked off by the straight dotted lines on the right side of the figure. *A*, The superior compartment, extending from the aryepiglottic folds to the superior vocal cords (ventricular bands); *B*, the cavity of the ventricle, bounded above by the superior vocal cord, below by the inferior or true vocal cord, and externally by the elastic membrane of the larynx; *C*, the inferior or subglottic compartment, extending from the true vocal cord to the inferior border of the cricoid cartilage; 8, edge of the superior vocal cord; 9, edge of the inferior vocal cord. Below the true vocal cord is seen the *thyro-arytenoideus* muscle.

the male is about one-half inch at the posterior portion when the cords are separated to their fullest extent. Through the glottis can be seen the anterior portion of the cricoid and a few of the superior rings of the trachea and at times the whole anterior portion of the trachea as far down as the bifurcation. Below the glottis the space widens and is oval laterally, but gradually approaches a circular form as it extends toward the trachea.

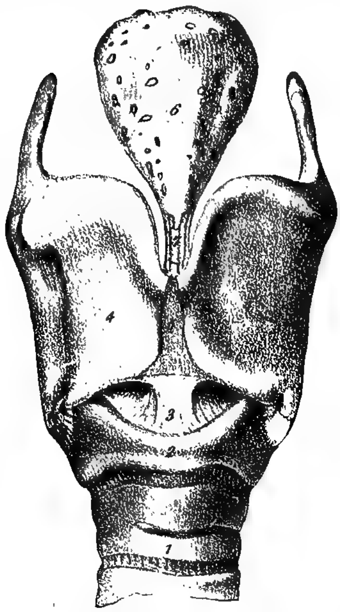

Fig. 3104.—Anterior View of the Cartilages of the Larynx. 1, Upper rings of the trachea; 2, anterior arch of the cricoid; 3, anterior portion of the cricoid-thyroid membrane (conoid ligament); 4, 4, lateral halves or alæ of the thyroid; 5, median portion of the thyroid; 6, epiglottis; 7, thyro-epiglottic ligament. (Luschka.)

Cartilages of the Larynx.—There are five principal cartilages of the larynx, the epiglottis, the thyroid, the cricoid, and the two arytenoid, and two pairs of very small unimportant cartilages, the cornicula laryngis (cartilages of Santorini) and the cuneiform cartilages (cartilages of Wrisberg). The thyroid, the cricoid, and the two arytenoid cartilages are of hyaline cartilage and liable to become ossified with age, while the epiglottis and the four small cartilages are of a fibrous nature.

The Thyroid Cartilage, the largest in the larynx, consists of two large quadrilateral symmetrical plates called alæ, which unite anteriorly at an angle of 85° to 95° and form the greater portion of the front and sides of the larynx.

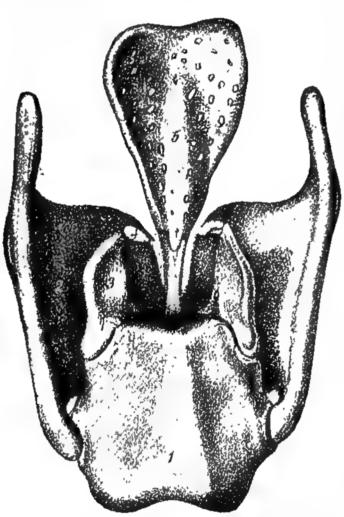

Fig. 3105.—Posterior View of the Cartilages of the Larynx. 1, Broad posterior arch of the cricoid; 2, internal surface of the ala of the thyroid; 3, arytenoid cartilage; 4, corniculum laryngis (cartilage of Santorini); 5, the posterior surface of the epiglottis. (Luschka.)

The alæ present an external flattened surface, marked by a rather indistinct oblique line, running from the inferior tubercle at the lower anterior border upward, outward, and backward to the superior tubercle at the posterior part of the superior border. This ridge gives attachment below to the sterno-thyroid, and above to the thyro-hyoid muscle, and just below this line are attached a part of the inferior constrictor of the pharynx and the stylo-pharyngeus. The internal surfaces are more or less concave and smooth, and near the angle of union in front are attached the epiglottis, the thyro-epiglottidean and thyro-arytenoid muscles, and the true and false vocal cords. Of the borders, the anterior is the shortest, and, except for a bursa which is sometimes present, is subcutaneous. The upper is somewhat convex except for a well-marked concavity near the superior cornu. The posterior extends above into a long delicate process, the superior cornu, which gives attachment at its extremity to the thyro-hyoid ligament, and terminates below in a short and thick process, the inferior cornu, presenting on the inner side a small oval facet which articulates with the side of the body of the cricoid. The lower border is nearly straight and is notched near the inferior cornu. It gives attachment anteriorly to the crico-thyroid membrane and laterally to the crico-thyroid muscle.

Fig. 3106.—Posterior View of the Cricoid and Arytenoid Cartilages, showing the Attachment of the Arytenoideus Muscle. 1, Cricoid; 2, arytenoid; 3, corniculum laryngis; 4, arytenoideus muscle. (Luschka.)

The Cricoid Cartilage, much thicker and stronger than the thyroid cartilage, forms the lower and greater part of the posterior portion of the larynx. The anterior portion is rounded and convex in shape and measures vertically about one-fifth of an inch. The external surface at the front and sides is smooth and gives attachment to the crico-thyroid muscles and inferior pharyngeal constrictors. Posteriorly, it rises until its vertical diameter is about three times that of the anterior portion. It also increases in thickness and forms the signet portion of the ring. This shows a depression near the middle on the superior border, on either side of which, looking upward and outward, is an elongated, oval and slightly convex facet for articulation with the arytenoid cartilages. At the middle of the posterior surface is a slight vertical ridge to which are attached a few of the longitudinal fibres of the œsophagus. On either side of this are depressions which are occupied by the posterior crico-arytenoid muscle; and just outside of these are the slightly raised oval facets for articulation with the inferior cornua of the thyroid cartilage. The whole interior surface is smooth and covered with mucous membrane.

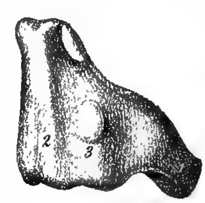

Fig. 3107.—Lateral View (right side) of the Cricoid Cartilage. 3, Articular surface for the inferior cornu of the thyroid; 4, articular surface for the base of the arytenoid. (Luschka.)

The Arytenoid Cartilages, two in number, are situated at the posterior superior portion of the larynx, and are the most active of all the cartilages in tuning the larynx for the production of sound. To them are attached the vocal cords and all of the muscles controlling their movements except the crico-thyroid. In shape they are three-sided pyramids and are about half an inch high and one-fourth of an inch wide. They articulate near the outer portion of the base with the facets on the superior surface of the cricoid, and their inner surfaces are nearly parallel. At each apex is situated the cartilage of Santorini. The inner surface, which is the narrowest of the three, is triangular in shape and nearly flat. It is covered with mucous membrane. The anterior surface has a triangular ridge at the junction of the lower and middle thirds, above and below which are concavities. Near the inner end of this ridge

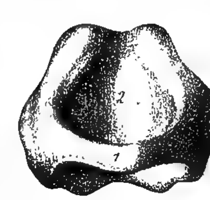

Fig. 3108.—Anterior View of the Cricoid Cartilage. 1, The anterior arch; 2, the posterior arch. (From Luschka.)

is attached the ventricular band. The thyro-arytenoid muscle is attached to the rest of the surface. The posterior surface is triangular, broad, and concave from above downward and gives attachment to part of the

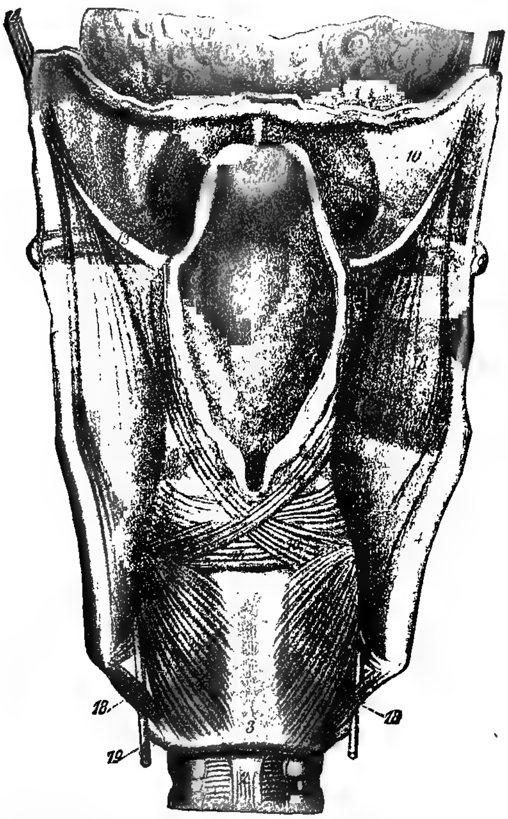

FIG. 3109.—Posterior View of the Larynx. The pharynx and mucous membrane are removed. 1, Trachea; 2, posterior crico-tracheal ligament; 3, cricoid; 4, posterior border of the thyroid; 5, epiglottis; 6, great cornu of the hyoid bone; 7, root of the tongue; 8, thyro-hyoid; 9, hyo-epiglottic membrane; 10, hyoglossal membrane; 11, middle glosso-epiglottic ligament; 12, lateral glosso-epiglottic ligament; 13, pharyngo-epiglottic fold; 14, stylo-laryngeus muscle; 15, arytenoideus muscle; 16, 16, crossing bundles of the aryteno-epiglottideus (*constrictor vestibuli laryngis*); 17, posterior crico-arytenoideus muscle; 18, 18, a few slender bundles, crico-thyroideus, posticus, or kerato-cricoideus of Merkel; 19, inferior laryngeal nerve. The aryepiglottic folds are seen reaching from the sides of the epiglottis to the arytenoid eminences, and bounding the superior orifice of the larynx, the *vestibulum laryngis*. (Luschka.)

arytenoid muscle. The whole base is slightly concave, with a smooth, more marked concavity near the outer portion for articulation with the cricoid cartilage. The anterior angle extends into a horizontal process (the vocal process), to which the vocal cord of that side is attached. The external angle, which extends outward and backward, forms a short and rounded process (the muscular process), to which are attached the posterior and lateral crico-arytenoid muscles.

The Epiglottis is a thin leaf-like cartilage which is attached to the inside of the thyroid cartilage just below the superior median notch. It is inside of, and attached to, the body of the hyoid bone. During respiration it is nearly vertical, but during deglutition as the larynx is drawn upward it drops backward and more or less completely closes the laryngeal opening. The anterior surface is covered by mucous membrane which is reflected on to the sides and base of the tongue, forming the lateral and median glosso-epiglottidean ligaments. The posterior surface is concave from side to side and convex from above downward. There are numerous small pits, sometimes perforating the cartilage, which lodge small glands. The mucous membrane is smooth and at the sides forms the aryteno-epiglottidean folds.

The *cartilages of Santorini*, two small conical nodules of fibro-cartilage, articulate with the tip of the arytenoid cartilages and are sometimes firmly united to them. The aryteno-epiglottidean folds are attached to these cartilages and enclose the *cartilages of Wrisberg* at a short distance in front of this attachment. These latter cartilages give rise to the elevations which are plainly seen in the laryngeal image.

Ligaments.—The cartilages of the larynx are bound together and to the hyoid bone above, and the trachea below, by fibrous bands and membranes. The thyroid cartilage is attached to the hyoid bone by a broad central membrane and two lateral rounded ligaments. The thyro-hyoid ligament is a broad fibrous and slightly elastic membrane, thick in the middle where it is subcutaneous, and thin and loose at the sides where it is pierced by the superior laryngeal vessels and nerve. It is attached below to the whole upper edge of the thyroid cartilage, and above it passes behind the posterior surface of the hyoid bone, being separated from it by a synovial bursa, to be attached to its upper surface. This allows the larynx to be drawn upward within the hyoid bone. The lateral thyro-hyoid ligaments are two rounded elastic cords just back of the middle ligament. They connect the superior cornua of the thyroid cartilage with the extremities of the great cornua of the hyoid bone.

The epiglottis is connected with the receding angle of the thyroid cartilage by a long rounded bundle of fibro-elastic tissue, the thyro-epiglottic ligament. It is also attached to the hyoid bone by a fibro-elastic membrane extending from near the apex of its anterior surface to the upper surface of the body of the hyoid bone. There are two lateral folds and one median fold of mucous membrane, already mentioned, which attach the epiglottis to the base of the tongue.

FIG. 3110.—Right Lateral View of a Dissected Larynx. The ala of the thyroid is removed. 1, Cricoid; 2, thyroid; 3, arytenoid; 4, epiglottis; 5, hyoid bone; 6, posterior crico-arytenoid muscle; 7, aryteno-epiglottideus muscle; 8, the lateral crico-arytenoideus; 9, thyro-arytenoideus. The other fibres, seen running in various directions, are inconstant in their distribution. (After Luschka.)

The crico-thyroid membrane and two capsular ligaments bind the thyroid and cricoid cartilages together. The crico-thyroid membrane, triangular in shape, is thick in front where it joins the cricoid and thyroid cartilages, and thin at either side where it extends from the cricoid cartilage to the inferior margin of the true vocal cords, and is joined with them at their anterior insertion into the thyroid cartilage. Anteriorly the crico-thyroid membrane is subcutaneous and is crossed horizontally by a small arterial branch which forms an anastomosis between the crico-thyroid arteries of either side. At the sides the crico-thyroid membrane is covered by the crico-thyroid and crico-arytenoid muscles. The capsular ligaments are lined with synovial membrane, and bind the articulations of the in-

ferior cornua of the thyroid with the sides of the cricoid cartilage. A loose capsular ligament lined with synovial membrane and strengthened posteriorly by a strong band, the posterior crico-arytenoid ligament, connects the arytenoids with the cricoid cartilage.

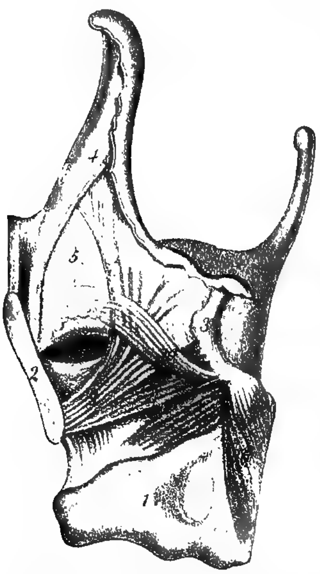

FIG. 3111.—Lateral View of the Laryngeal Muscles. 1, Cricoid; 2, thyroid; 3, arytenoid; 4, epiglottis; 5, elastic membrane of the larynx; 6, posterior cricoid-artenoid; 7, lateral crico-arytenoid; 8, thyro-arytenoid; 9, thyro-epiglottideus; 10, fine fibres spreading out in the elastic membrane (*ary-membranosus*). (Luschka.)

Muscles. — The larynx as a whole is moved and also fixed in its varying positions by muscles which attach it to the hyoid bone above, the sternum below, and the region of the fourth and fifth cervical vertebræ behind. It is elevated principally by the thyro-hyoid muscle and depressed by the sterno-thyroid; and the two muscles, acting at the same time, tend to hold it firmly in a fixed position.

There are also some muscular fibres, forming the so-called laryngo-pharyngeal muscle, which are attached to the posterior border of the thyroid cartilage and pass backward around the pharynx to be inserted into the vertebræ behind. The sterno-hyoid, the omo-hyoid, the two lower constrictors of the pharynx, the stylo-pharyngeus, and the palato-pharyngeus also act more or less upon the larynx as a whole. The thyro-hyoid is a small quadrilateral muscle arising from the lower border of the body and greater cornu of the hyoid bone and is inserted into the oblique line on the ala of the thyroid cartilage; and the sterno-thyroid has its upper attachment to this same oblique line and is attached below to the posterior surface of the manubrial portion of the sternum, below the attachment of the sterno-hyoid. The middle thyroid vein is situated along its inner border.

The muscles which change the shape of the larynx and act directly upon the vocal cords are the crico-thyroid, the crico-arytenoideus posticus, the arytenoideus lateralis, the arytenoideus, and the thyro-arytenoideus.

The crico-thyroid, a short triangular muscle, is attached below to the anterior and lateral portion of the cricoid cartilage. From this the fibres pass upward and outward and divide into two bundles, the anterior being attached to the inner lower margin of the thyroid cartilage and the posterior to the anterior border of the lower cornu. Whether this muscle depresses the thyroid or elevates the cricoid it increases the length and tension of the vocal cords. The posterior crico-arytenoid muscle is attached to the muscular process of the arytenoid cartilage behind that of the lateral crico-arytenoid. The fibres spread like a fan, the upper nearly horizontal and the lower nearly vertical, and are attached to the broad depression on the posterior surface of the cricoid cartilage. This muscle draws the muscular process of the arytenoid backward and inward, and thus by rotating the vocal processes outward widens the rima glottidis. The lateral crico-arytenoid, from its attachment to the muscular process and adjacent part of the anterior surface of the arytenoid cartilage, spreads out and passes downward and forward to be attached to the upper slanting surface of the cricoid cartilage as far back as the articulation of the arytenoid. The action of this muscle is to draw the muscular process of the arytenoid forward and downward and, by rotating the vocal process inward, to approximate the vocal cords. The action of this muscle is antagonistic to that of the posterior crico-arytenoid, and when the two act simultaneously the arytenoid is not rotated but is drawn inward and the glottis is narrowed.

The arytenoideus is a single muscle which passes between the posterior outer borders of the arytenoid cartilages. The deep fibres are transverse but the superficial pass obliquely from the base of one to the apex of the other arytenoid. Some of these fibres pass around the cartilages and join with the fibres of the thyro-arytenoid or the aryteno-epiglottic muscle. The arytenoideus draws the bases of the arytenoid cartilages together.

The thyro-arytenoid muscle contains both longitudinal and transverse fibres and is made up of internal and external portions which are sometimes described as two distinct muscles. The long fibres of the inner portion arise in front from the receding angle of the thyroid cartilage, a few sometimes from a nodule of fibrous tissue in the anterior portion of the cord, the cartilage of Luschka. They pass backward with a slight outward curve and are attached to the whole length of the vocal process and adjacent outer surface of the arytenoid. The whole inner border is attached to the vocal cord. The outer portion arises from the thyroid cartilage near that of the inner, and also from the crico-thyroid membrane. Some of the fibres pass backward and are inserted into the lateral border and muscular process of the arytenoid cartilage, others pass obliquely upward to the aryteno-epiglottidean fold, and still others pass vertically in a thin layer around the ventricle and sacculus, ending in the false cord. There is one set of fibres which pass from the anterior attachment outward around the sacculus laryngis and are inserted into the side of the epiglottis. On account of the various directions and attachments of this muscle its action is rather complicated. The longitudinal fibres of the inner portion tend to bring the edges of the vocal cords together, while the short oblique fibres tend to tighten them.

The Blood Supply.—The superior thyroid artery gives off a branch, the superior laryngeal, which passes with the superior laryngeal nerve between the great cornu of the hyoid bone and the thyroid cartilage through the thyro-hyoid membrane, and supplies the structures of the anterior superior portion of the larynx. The inferior laryngeal artery also arises from the superior thyroid,

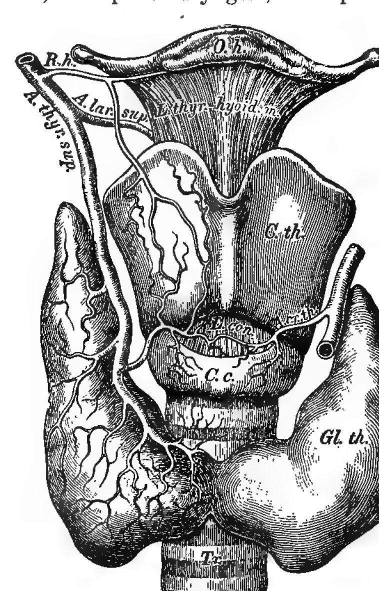

FIG. 3112.—Arteries of the Larynx. (From Luschka.) *C. th.*, Thyroid cartilage; *Gl. th.*, thyroid gland; *Tr.*, trachea.

near the lower border of the thyroid cartilage. It divides into two branches, one anastomosing with its fellow of the other side and the other with branches of the superior laryngeal. The posterior laryngeal artery, a branch of the inferior thyroid, passes with the recurrent laryngeal nerve; it then divides, near the crico-arytenoid articulation, into two branches which anastomose with branches of the superior laryngeal artery.

The laryngeal veins are associated with the arteries and empty into the internal jugular through the superior, middle, and inferior thyroid.

Lymphatics.—The lymphatics may be divided into two sets. The upper pierce the thyro-hyoid membrane and empty into the glands located near the bifurcation of the common carotid artery. The lower, after piercing the crico-thyroid membrane, end in glands in front of this membrane or at the side of the cricoid cartilage.

Nerves.—The pneumogastric nerves, joined by sympathetic fibres, give off the superior laryngeal nerves, which supply the mucous membrane, the crico-thyroid muscles, and a part of the arytenoideus muscle, and the inferior laryngeal nerves which supply all of the other muscles of the larynx. *Edgar M. Holmes.*

LARYNX, DISEASES OF: ABSCESS.—Abscess of the larynx is a circumscribed collection of pus due to an inflammatory process which has developed principally in the submucous tissue. *Laryngitis submucosa acuta* may culminate, aside from abscess, in either acute œdema of the larynx or in diffused phlegmonous infiltration, and when abscess is present these conditions to some degree are usually associated with it. Very rarely is there more than one abscess. Both acute and chronic suppuration may also be dependent upon perichondritis and its various constitutional and local causes, but this type of abscess will be reserved for consideration in connection with the subject of perichondritis.

Etiology.—Any of the causes of acute laryngitis, any exposure leading to infection, can by a more intense action involve the submucous tissue. It is probable, however, that the microbic invasion which is incidental to "taking cold," vocal abuse, inhalation of steam, smoke, or badly vitiated air, damage by foreign bodies and corrosive poisons, may be different from that which occurs with some of the graver forms of laryngitis. Thus, from the similarity of acute phlegmonous laryngitis to recognized erysipelas it is thought that the streptococcus erysipelatis may be responsible for it. However, the ordinary pyogenic cocci are doubtless adequate to produce the circumscribed abscess. Secondarily, acute submucous laryngitis, possibly leading to abscess, may result, by contiguity, from neighboring infections, *e.g.*, peritonsillar abscess, phlegmonous pharyngitis, Ludwig's angina, etc. It follows syphilitic and tuberculous ulceration of the larynx doubtless by secondary pyogenic infection. It occurs as a serious complication of typhoid fever, typhus fever, septicæmia, ulcerative endocarditis, erysipelas, smallpox, scarlet fever, and measles. It is liable to follow contusions and fractures of the cartilages due to external injury. Marked systemic depression and sepsis are predisposing conditions.

Pathological Anatomy.—When an abscess forms on the lingual surface of the epiglottis it extends to the valleculæ, in one of which it may rupture. It does not extend over the free edge of the epiglottis to the laryngeal surface. It may point externally at the side of the neck. When it is due to perichondritis, fragments of necrotic cartilage are likely to be exfoliated.

Symptoms.—Apart from the symptoms of simple laryngitis a submucous inflammation first manifests itself by increasing dyspnœa. The formation of an abscess is indicated by tenderness to pressure and by severe pain on swallowing and speaking. If the abscess is on the lingual surface of the epiglottis there may be no dyspnœa, only very painful dysphagia; if it is on the aryepiglottic fold the dyspnœa may be only inspiratory. If the abscess is within the larynx and is not opened, it is likely to cause suffocation; but it may burst spontaneously. The development is sometimes quite gradual, or again the suppuration may culminate within a very few days. The temperature varies with the extent of inflammation and with the nature of the underlying affection.

Laryngeal Image.—At first the appearance is that of submucous inflammation, more or less diffused, although if the inflammation is circumscribed an abscess is more strongly indicated. Pointing and a yellow color are the only certain laryngoscopic signs of abscess.

Diagnosis.—The differentiation from other obstructive conditions of the larynx must be based largely upon the laryngoscopic appearance. The yellowish point of an abscess is less translucent than simple œdema and the swelling tends to be circumscribed, unlike that of diffuse phlegmonous inflammation. In subglottic laryngitis the swelling is bilateral and symmetrical. Fluctuation is discernible only when the abscess is at the radix linguæ. Severe pain indicates an abscess, but perichondritis should also be remembered in this connection. In doubtful cases an exploratory puncture with a laryngeal lancet is justified. In children the epiglottis and aryepiglottic folds can be palpated, thus serving to exclude an abscess of these parts or to establish its exact location. Retropharyngeal abscess pressing upon the larynx should be kept in mind.

Prognosis.—In all the thirteen cases observed by Mackenzie, the symptoms were very severe, but all terminated in recovery; in nine the abscess was opened, and in four it burst spontaneously. Nevertheless, without surgical interference—either evacuation of the abscess or when necessary a prompt tracheotomy—the prognosis would be grave.

Treatment.—While the disease is still in the stage of *laryngitis submucosa acuta*, appropriate measures to prevent the possible formation of an abscess are absolute rest for the voice and cold applications. Cold wet cloths frequently reapplied may be used externally, and cracked ice may be dissolved in the mouth. Cold applications, however, should not be indefinitely prolonged. When suppuration is obviously imminent hot applications are more comforting. If œdema is a marked feature scarification is usually recommended, but the benefit is slight. A four-per-cent. cocaine spray affords temporary relief by causing the œdematous tissue to shrink. The atmosphere should be kept moist. The abscess when formed should be opened under laryngoscopic observation by means of a laryngeal lancet. When it is very large, care should be taken not to evacuate it too rapidly as there is danger of suffocation by inspiration of the pus. If there is pronounced dyspnœa and evacuation of the abscess is not feasible, the only efficient resource is tracheotomy. This should not be too long delayed, on account of the danger of fatal congestion of the lungs secondary to stenosis of the larynx. Intubation is not a satisfactory substitute for tracheotomy in these cases. *W. E. Casselberry.*

LARYNX, DISEASES OF: ACUTE LARYNGITIS.—(Synonyms: Acute laryngeal catarrh, pseudo croup, laryngorrhœa, mucous laryngitis, and sore throat.)

Definition.—Acute laryngitis is an acute inflammation of the mucous membrane lining the larynx, characterized by a moderate degree of exudation, with or without some slight febrile disturbance. The characteristics of the disease in children differ somewhat from those of the adult, but these variations are not sufficient to require the separate study of the two classes, and they will therefore be considered here under a common title. In the adult acute laryngitis seldom threatens life, although the dyspnœa and loss of voice are often unduly alarming to the patient. In childhood the disease occurs in three different forms, the mild, the severe, and the grave.

Etiology.—The most common predisposing cause is some pathological condition of the nose or naso-pharynx, the occasional or continued mouth-breathing which accompanies these inflammations of the upper air tract, rendering the larynx sensitive to the more immediate causative factors. The laryngeal mucous membrane in these cases of improper breathing is subjected to more

irritation than is its due by the dry and unfiltered air which passes over it, and this induces a more or less severe chronic inflammation in this locality; and the various exciting causes of laryngitis then find a ready soil in the existing chronically inflamed membrane. The disease occurs more often in males than in females, and more often in adult life than in childhood. It is more apt to be grave in children, and in them occurs oftenest between the ages of two and four years and with equal frequency in the children of either sex. Amongst the immediate causes of acute laryngitis are exposure to cold, depressed general vitality, inhalations of irritating dust, vapors, steam or gases; the dust from our modern asphalted streets, the vapors of chlorine, iodine, ammonia, or sulphur, and the excessive use of alcohol are exciting causes. Overtaxing the voice by public speaking, singing, or shouting is a common cause. Wetting of the feet may be rated as one of the most frequent causes. Previous attacks make the patient more liable to subsequent ones. Among the general causes may be mentioned rheumatism, the eruptive fevers, influenza, and hay fever. The introduction of drugs like the iodide of potassium into the general economy or the introduction of various irritating drugs locally into the larynx may bring on an attack.

Pathology.—The pathology is similar to that of inflammations of mucous membranes elsewhere, there being a primary hyperæmia with scanty secretion, the *dry stage*, and after that a second, or *moist stage*, caused by the pouring out of serum from the distended blood-vessels and the increased secretion of mucus from the glands. The desquamation of epithelial cells and the exudation of leucocytes give the whitish color and the tenaciousness to the secretions of the later stages. While there may be some desquamation of epithelium, there are as a rule no deeper destructive changes. The swollen membrane encroaches on the breathing space, thus interfering to some degree with the respiration, and the dry feeling of the early stages adds to the discomfort. The inflammation may be general or confined to certain localities. The interarytenoid commissure shows the most decided changes and the ventricular bands or aryepiglottic folds come next. These areas show more marked changes because of the loose attachment of the mucous membrane to the subjacent tissue in these regions, and also of the fact that the unusual mobility of the commissure favors desquamation of the epithelial cells. The submucous layers are not often affected, the inflammation being more commonly confined to the superficial layers, and so too the supraglottic region is more often affected than the subglottic—which is fortunate, as the subglottic variety is accompanied by grave symptoms. In children the pathological changes are exaggerated; the exudation, being more plastic, becomes almost pseudomembranous; and, owing to the relative smallness of the breathing space, respiration is more interfered with, this resulting in stridor and spasms of respiration, which add to the gravity of these cases. The mucous membrane of the epiglottis does not as a rule show marked inflammatory change, but in chickenpox yellowish vesicles may appear in this region, while in measles and Rötheln the mucous membrane partakes of the cutaneous characteristics. Stoerck described a "fissura mucosa" of the interarytenoid space which occurs when there is an erosion in this region, and the writer has seen at least two cases of this in which there was marked hemorrhage.

Symptoms.—The symptoms are somewhat more aggravated in childhood than in adult life. This is owing partly to the narrowness of the lumen in children, partly to the excess of lymph cells in their mucous membranes, and partly to the muscular deficiency which makes it more difficult for them to throw off the tenacious exudate. In the adult the chief complaint is the disturbance in vocalization, the voice becoming hoarse and husky or even completely lost, the degrees of loss depending upon the progress of the disease. Some tones can usually be elicited, but talking is difficult and requires a manifest effort. This is owing to the thickening and congestion of the mucous membrane which interferes with the proper approximation of the cords and with their resilience. The thickening of the arytenoid commissure and of the subglottic mucous membrane especially interferes with clear speech, and at times the ventricular bands may become so swollen as to lap over the true cords and add to the disturbance. It is possible that the loss of nerve tone also adds to the difficulty in controlling the muscles of speech, and at times too there seems to be an hysterical element in the exaggerated speech deficiency.

Cough is an occcasional symptom of acute laryngitis. This is due to the swelling of the mucous membrane and the excessive secretion in the later stages, but severe coughing usually implies an extension of the disease to the subglottic region or to the trachea or bronchi. The cough is apt to be harsh, metallic, and irritating, and may be due to congestion in any of the four cough centres. There may be some distress in the larynx accompanying attempts to speak or upon coughing, but this is not marked as a rule. There is not apt to be tenderness or pain externally, and respiration in adults is little interfered with except when there is a concurrent œdema glottidis. Expectoration is scanty and serous at first, later becoming mucous and more copious and, when the bronchi are involved, muco-purulent and abundant. The constitutional symptoms when present are very mild in the adult, consisting of slight fever with possibly some anorexia, headache, and general malaise.

In children the supraglottic variety is similar to the acute laryngitis of adults, but the subglottic form is more serious. The first marked symptoms are more often those relating to respiration. This becomes spasmodic and there may even be attacks of suffocation. These suffocative or croupous attacks occur more often at night and imply subglottic inflammation. The first night attack is apt to be the most severe, and although there may be subsequent attacks on three or four succeeding nights, each is apt to be less severe than its predecessor. These night exacerbations are brought on by the mouth-breathing. In the subglottic form cough sets in earlier, it is croupy in character and is probably due to the approximation of two opposite portions of swollen subglottic mucous membrane. The cough is harsh, dry, and husky, even when the child is aphonic. Children subjected to these attacks are especially apt to have lymphatic enlargements in the naso-pharynx, or chronic inflammations of the nasal mucous membrane. One attack predisposes to another, and children are more apt than adults to have febrile disturbances.

Diagnosis.—The diagnosis is made from alterations in the voice, from the fact that the cough, if present, is dry, and not accompanied by secretion as in bronchitis, and from the absence of the constitutional symptoms present in syphilis, tuberculosis, etc. The most important aid to diagnosis, however, is the laryngeal image, by means of which laryngitis symptomatic of the more severe constitutional disturbances may be recognized or eliminated. This image can usually be obtained even in children. The writer has at times been enabled, in a child, to get a good laryngeal image with the largest size mirror, one inch and a half in diameter, when smaller sizes had failed. The laryngoscope reveals a generally red and congested mucous membrane, and this appearance is more marked in localities where the mucous membrane is loosely attached. The cords vary in color, they appear slightly thickened, and somewhat sluggish in their movements. The color of the mucous membrane varies from a delicate pink to a brick red, or a beefy color. The vocal cords may be pink or may show blood-vessels running over the elastic tissue or may be ecchymotic and show bleeding spots from the rupture of the capillaries due to coughing. This latter form is the so-called "hemorrhagic laryngitis." If the interarytenoid desquamation has been excessive a slit like a knife-cut may show in the median line, and this is apt to be found in cases of severe bleeding like the two referred to above. The fact that the vocal cords of public speakers are often habitually red must not be overlooked in making this

diagnosis. There may at times be local desquamations in patches scattered irregularly over the surface of the mucous membrane. The changes in the interarytenoid space are usually the most marked. It is here that desquamation is more apt to be seen, and this region may in the later stages be covered by a tenacious mucus. In the subglottic variety the bulging subglottic mucous membrane may be plainly seen when the cords are abducted.

Differential Diagnosis.—From a study of the above-mentioned subjective and objective symptoms the diagnosis should easily be made. The possibility of diphtheria, measles, scarlet fever, or the more rare eruptive fevers, should be borne in mind. In the adult the diagnosis should be easy.

The *prognosis* is good as to recovery. The disease is never fatal in adults and rarely so in children, but if neglected it may become chronic or may lead to trachitis or bronchitis.

TREATMENT.—In the early acute stages topical applications must be used with great care. Catharsis may be promoted by the mild chloride of mercury in half-grain doses combined with three grains of bicarbonate of sodium; this to be repeated every two hours until it acts. The old "cold" remedies, quinine and Dover's powder, may be tried, together with a hot foot bath with or without mustard. A pleasanter and often more efficient remedy is aconite or aconitine in full physiological doses.

Local treatment consists in thorough though gentle cleansing of the mucous membrane of the upper respiratory tract followed by the application of sedative and astringent medicines. The nose and naso-pharynx should be thoroughly cleansed by means of an alkaline antiseptic spray such as: ℞ Acidi borici, gr. v.; sodii bicarb., gr. x.; Listerine, fl. ʒ vi.; aquæ destillat., fl. ℥ vi.; or a solution of Seiler's tablets; or diluted Dobell's solution may be used for this purpose. This should be gently blown out, care being taken to allow the nostril to be entirely free from external pressure during the blowing process. If the nasal mucous membrane is turgescent, a second spray should be used, something like the following: Cocaine hydrochlorate, gr. iiss.; acidi borici, gr. v.; aquæ destillat, fl. ℥ i. Just enough of this solution should be used to cover the turbinates and not enough to pass into the throat. This should be allowed to rest undisturbed for five minutes, after which a watery solution of suprarenal powder (gr. x.–℥ i.) should be gently applied to the turbinates either with a cotton-tipped probe or in spray. The solution of suprarenal powder will decompose in a few hours, unless it be made more lasting by an addition of one-per-cent. resorcin or of some other preservative. An astringent and sedative solution, such as the following, may now be sprayed into the pharynx and inspired into the larynx: ℞ Ol. gaultheriæ, gtt. iv.; zinci sulph., gr. v.; antipyrin, gr. xx.; aquæ destillatæ, fl. ℥ ij. A small quantity of the powdered mild chloride of mercury barely sufficient to give them a grayish hue, may be insufflated over the turbinates, and finally the nares may be sprayed with an oily solution of ℞ Menthol (crystals), gr. v.; liq. petrolei, fl. ℥ i.

After the mucous membrane has lost the extreme sensitiveness of the early stages a watery solution of sulphate of zinc, two to four per cent., may be gently applied to the laryngeal mucous membrane on a curved cotton-tipped probe. The above local treatment is usually all that is necessary in these cases and should of course be carried out by the physician himself. For home use the compound zinc solution above mentioned may be of service. It may be assisted by the inhalation of steam, which may be medicated by a solution such as the following: ℞ Menthol, gr. xv.; ol. eucalyptol, ʒ ij.; terebene, fl. ʒ iij.; tr. benzoin. comp., fl. ℥ iij., a teaspoonful of which may be added to a pint of boiling water. For the purpose of these steam inhalations a tin cup, spirit lamp, and paper cone are all that is necessary. The patient should not be allowed to expose himself to cold air for from half an hour to an hour after the use of steam inhalations.

The ice pack or Leiter's coil sometimes aids in allaying symptoms in the subglottic variety of acute laryngitis. Applications by the probe may be carried between vocal cords into the subglottic region. These applications may be used to promote emesis in the croups of children and are superior for this purpose to the old-fashioned ipecac and mustard given internally, as they give the desired local effect without the constitutional after-disturbances.

Many methods have been suggested hastily to clear the throat of one who must use it in public. None of them, however, is infallible, and all of them are to be discouraged as far as possible. Rest of the voice and body in a room heated to a temperature of about 70° F. is amongst the best remedies for this. The air should be properly renewed and kept moist. The patient should drink freely of non-aerated water. The emunctories should be properly cared for, and alcohol and tobacco should be interdicted. The local treatment outlined above should be carried out. At times the desired effect may be more quickly attained by the use of aconite or aconitine to the physiological limit, and by the application of the galvanic current to the external aspect of the larynx.

The supraglottic form of acute laryngitis in children is usually trivial, and a mild spray such as the compound Listerine mentioned above may be used in the nose and throat. The Politzer bag may be applied to one nostril and compressed while the other is allowed to remain unobstructed; this forces the secretions from the nose and naso-pharynx through the unobstructed nostril, then a large soft wad of cotton on the applicator may be soaked with a one- to two-per-cent. solution of sulphate of zinc and pressed against the pharyngeal wall, the zinc thus diffusing itself will have the desired effect of clearing the throat of excessive secretion. The child should be kept in a room the temperature of which is maintained at 70° F. and the air of which is kept moist by the croup kettle, slacking lime, or some similar device. Applications of camphor and oil of amber, or simply of suet, applied locally over the bridge of the nose and the laryngeal region, will sometimes be of assistance in these cases.

In the more serious subglottic variety of acute laryngitis, or pseudocroup, in children, more active measures are at times necessary. The routine treatment suggested above may be preceded by a general hot bath to which a small amount of mustard has been added. It may be necessary to pass the curved cotton-tipped probe into the larynx, emesis being brought about in this way. Hot water may be applied freely to the external throat by sponge or cloths. It must be borne in mind that these so-called croupy children have some defect of the nose or naso-pharynx, and these defects should be corrected in the intervals between the attacks. As an adjuvant to the above a spray of suprarenal solution, gr. x.–℥ i., may be used in the croupous child every two or three hours. Hydrargyrum cum creta, or calomel and soda, when administered internally, aid materially in reducing the quantity of exudate. Tincture of chloride of iron and glycerin may be substituted for the zinc solution used above. In the more severe cases tracheotomy or intubation may be necessary; intratracheal injections of menthol-creosote and liq. petrolei may at times be of use in these cases of the subglottic variety.

ŒDEMATOUS LARYNGITIS AND PHLEGMONOUS LARYNGITIS.—(Synonyms: Œdema glottidis; œdema of the larynx, acute phlegmonous laryngitis, laryngeal cellulitis, purulent or suppurative laryngitis.) Œdematous laryngitis is an acute inflammation of the laryngeal mucous membrane, which is characterized by serous infiltration into the areolar tissue of the mucous membrane. It is at times idiopathic, or it may have a local cause, or it may be secondary to some general disease. In infected cases there may be pus formation resulting in the so-called phlegmonous laryngitis, the suppuration in these cases being unilateral as a rule. Œdema is accompanied by the usual symptoms of distress caused by difficult breathing, and there may be some febrile disturbances. This disease occurs more often in the acute form, though it may at times become chronic.

Etiology.—Any disease which causes dropsy or anasar-

ca in other parts of the body may cause an œdema of the larynx. It has been said to occur idiopathically, but this form is probably the angioneurotic variety of Osler and others. Disease of the kidneys is one of the most com-

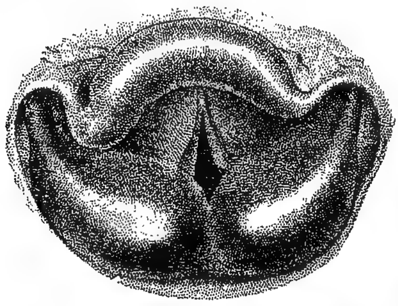

FIG. 3113.—General Œdema of the Larynx. (Browne.)

mon causes, since it is prone to bring about a venous turgescence in this region as well as elsewhere. Diseases of the heart, lungs, or liver which cause excess of venous pressure or damming back of the blood in the veins and consequent oozing of serum into the areolar tissue, may also bring about this laryngeal complication. External traumatisms, or foreign bodies in the larynx or the neighboring œsophagus, or the inhalation of irritating gases, vapors, or fluids are at times causes. The œdema may be secondary to tuberculosis, syphilis, scarlet fever, diphtheria, typhus or typhoid fever, smallpox, or streptococcal infections. In the phlegmonous variety some septic condition is likely to be the cause, such as erysipelas, tonsillitis, or pericervical inflammation. The angioneurotic œdema is probably caused by vaso-motor paresis due to a general neurotic condition.

Pathology.—There is a primary engorgement of the vessels and later a consequent leakage of serum into the perivascular areolar tissue; rarely this fluid is sanguineous. This leakage is naturally greater in the localities where the tissue is loosest, so that the most marked swellings are in the ventricular bands and the posterior surface of the epiglottis and to a lesser degree in the interarytenoid commissure. The epiglottis is nearly always involved, while the vocal cords are not often affected, noi is the subglottic region as a rule. In the phlegmonous variety the exuded serum undergoes purulent change

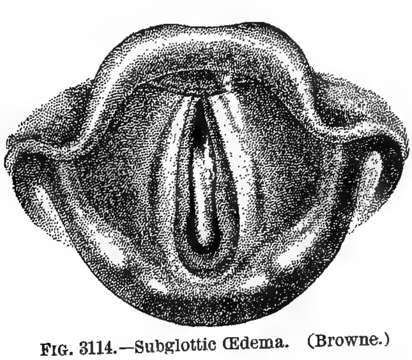

FIG. 3114.—Subglottic Œdema. (Browne.)

and an abscess is formed; and while, in the ordinary variety, the swelling is symmetrical, in these cases it is usually unilateral (Fig. 3114). At times the surrounding cervical tissues may become infiltrated with serum.

Symptoms.—The prominent symptoms are the dyspnœa, the impairment of the voice, the cough, and at times orthopnœa. The dyspnœa comes on suddenly as a rule, reaching its height in about thirty-six hours from its onset. Inspiration in the severe forms is more difficult than expiration, owing to the rolling in of the swollen mucous covering of the ventricular bands and epiglottis. The voice becomes deep and may later be lost entirely. The cough is very wheezy and labored, brings no relief from the symptoms, and is accompanied by but little expectoration. Pain is not usually present, although it may be experienced on swallowing or when the cervical tissues become infiltrated. As in other diseases which obstruct the breathing, the patient wears an anxious look, is usually restless, and is more comfortable in the sitting posture than when lying down. In the phlegmonous variety there is apt to be fever or even a chill. The laryngoscope reveals a swollen mucous membrane, smooth, glassy, and semitranslucent, not unlike the appearance of a myxomatous polyp. There are usually three prominent projecting folds formed by the epiglottis and the two aryepiglottic folds. Between these three folds is a triangular opening in which it is at times possible to see the true cords and the interarytenoid commissure. When the use of the laryngoscope is impracticable, which is rare, a digital examination may be necessary to disclose the true condition.

The *diagnosis* is made from the above symptoms and signs.

Treatment.—The local symptoms should be relieved by scarifications which may be made with the laryngeal scarifier (Fig. 3115) or with an ordinary curved bistoury protected close to the point with a wrapping of adhesive plaster. A solution of suprarenal powder, sulphate of

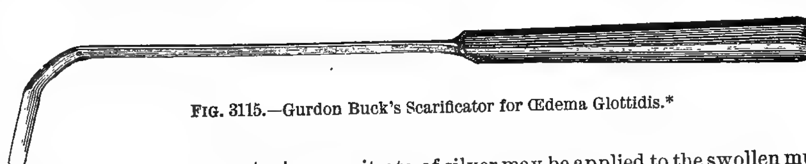

FIG. 3115.—Gurdon Buck's Scarificator for Œdema Glottidis.*

zinc, or nitrate of silver may be applied to the swollen mucous membrane. External applications of cold by means of the ice pack or Leiter's coil, may be of service. Free

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* The author's description of the procedure is quoted here in full:

"The following is the mode of performing the operation of scarifying, as employed in the cases about to be related.

"The patient being seated on a chair, with his head thrown back and supported by an assistant, he is directed to keep his mouth as wide open as possible; and if there be any difficulty in this respect, a piece of wood an inch and a fourth in width and half an inch in thickness, is to be placed edgewise between the molar teeth of the left side. The forefinger of the left hand is then to be introduced at the right angle of the mouth, and passed down over the tongue till it encounters the epiglottis.

"But little difficulty is generally experienced in carrying the end of the finger above and behind the epiglottis so as to overlap it and press it forward toward the base of the tongue. In some individuals the finger may be made to overlap the epiglottis to the extent of three-fourths of an inch.

"Thus placed, the finger serves as a sure guide to the instrument to be used, which is represented accurately in the accompanying plate. The knife is then to be conducted, with its concavity directed downward, along the finger till its point reaches the finger-nail. By elevating the handle so as to depress the blade an inch to an inch and a half farther, the cutting extremity is placed in the glottis between its edges; at this stage of the operation the knife is to be slightly rotated to one side and the other, giving it a cutting motion in the act of withdrawing it. This may be repeated two or three times on either side without removing the finger. The margin of the epiglottis, and the swelling between it and the base of the tongue, may be scarified still more easily with the same instrument, or scissors, curved flatwise, may be employed for these parts, guided in the same manner as the knife.

"Though a disagreeable sense of suffocatien and choking is caused by the operation, the patient soon recovers from it, and submits to a repetition after a short interval. In every instance the operation has been performed twice, and in some three times." ("Œdematous Laryngitis, Successfully treated by Scarifications of the Glottis and Epiglottis," by Gurdon Buck, Jr., M.D., Surgeon to the New York Hospital. From vol. i., p. 136, of Transactions of the American Medical Association, 1848.)

See also "Six Additional Cases of Œdematous Laryngitis, Successfully Treated by the Scarification of the Epiglottis," etc., by Gurdon Buck, M.D.; Transactions of American Medical Association, vol. iv., 1851, p. 277.

The small knob shown in the illustration was added at a later date, and is intended to serve as an aid to the operator in estimating, by the sense of touch, how far down the cutting end of the instrument has been introduced.

diuresis, catharsis, and diaphoresis should be promoted. For the latter purpose pilocarpine may be administered. The underlying constitutional symptoms should be treated according to the general principles laid down in each case. In a case recently seen by the writer prompt relief of the laryngeal condition followed artificial premature labor which was induced for the relief of the kidney symptoms. It may at times be necessary to resort to tracheotomy or intubation to save life. In these cases the former is usually to be preferred, as the relief is more rapid and is usually brought about with less inconvenience to the sufferer. *George C. Stout.*

LARYNX, DISEASES OF: BURNS, SCALDS, AND INJURIES.—Severe acute inflammation of the larynx, involving the submucous areolar tissue, may follow the swallowing of very hot liquids and of corrosive poisons, the inhalation of flame or of highly heated air, or the impaction of a foreign body.

The pathological condition commonly met with in the three accidents above-named is, practically, acute laryngeal œdema. The early symptoms are pain, dyspnœa, dysphagia, aphonia, and shock. Respiration is rapid and stridulous, the face pale and anxious, and the patient very restless. The symptoms may be mild at first but later they are severe, especially after the ingestion of caustic liquids. Often œdema of the larynx and fatal dyspnœa rapidly come on, or serious pulmonary complications quickly follow.

Mild cases may end in recovery in a few days. Death is apt to occur in from one to two days from dyspnœa or shock, or later from laryngitis, bronchitis, or pneumonia. The inhalation of flame or of steam is always a very serious complication of the other injuries, owing to the general depression and the mental shock which are likely to accompany such cases. Treatment should be at once instituted. Absolute quiet should be secured, digestion regulated, strength supported, and the patient carefully watched for the development of laryngeal and pulmonary symptoms. Many writers recommend the administration of a dose of calomel at the outset.

The sucking of cracked ice, the administration of a non-depressant emetic, and thorough scarification of the œdematous tissue, as described in the preceding article, have been highly recommended. Applications of cocaine must be used with great caution, on account of the depressing effect of this drug upon the heart. Extract of the suprarenal glands is very valuable. Of course, in case of the impaction of a foreign body the offending object must be removed. Too much stress cannot be laid upon the necessity for energetic treatment, and when the symptoms are urgent, immediate recourse should be had to tracheotomy or, better still, to intubation of the larynx after the method of O'Dywer (see *Intubation*).

Laryngitis from corrosive poisoning is frequently followed by extensive sloughing, and eventually by cicatricial contraction which may require more or less important surgical treatment for its relief. (See *Larynx, Diseases of: Stenosis.*) *D. Bryson Delavan.*

LARYNX, DISEASES OF: CHRONIC INFLAMMATION.—There is, to say the least, some diversity of opinion as to the etiology of chronic laryngitis—this diversity being mainly as to whether the chronic form is a secondary stage or a sequel of the acute attack or attacks, or whether it results from the propagation downward of the same disease of the naso-pharynx.

Seiler evidently adheres to the first supposition, viz., that the acute attack passes into the chronic, particularly in any case of depression of the general system; but he also admits that nasal obstruction or misuse or abuse of the voice may lead up to the same condition.

Cohen speaks of the development of chronic laryngitis from a series of attacks of acute laryngitis as a very rare occurrence, but he believes that it may be caused by phthisis, syphilis, or carcinoma, or may occur as an extension from bronchitis or tracheitis, and he thinks it is frequently idiopathic.

Mackenzie seems to lean about equally to both views, for he says that the disease may be a result of the acute lesion or be due to propagation from the pharynx. He also goes minutely into a consideration of many other causes, such as the prolonged use of the voice as in the case of clergymen and singers, the abuse of alcohol, the elongation of the velum, the breathing of impure or dusty air, the change of the voice in boys at puberty, and in the aged, etc., and he further states that it may be an accompaniment of syphilis, phthisis, carcinoma, polypi, etc.

Of the later writers Coakley—who divides chronic laryngitis into an hypertrophic and an atrophic form, and also into various other sub-forms according to the particular seat of inflammation, whether above or below the vocal cords—believes that the chronic laryngitis occurs either as a sequel of the acute form, or as a result of nasal catarrh, gout, rheumatism, syphilis, the inhalation of dust, alcoholism, etc., and he expresses no particular preference for either view.

Newcomb mentions as causes all affections of the upper air passages such as atrophic and hypertrophic disease of the nose, pharynx, and tonsils, and all impediments to normal respiration, the continued respiration of irritating substances, the excessive use of tobacco and alcohol (their moderate use he does not think responsible), severe or prolonged vocal exertion—such as speaking in the open air to large crowds, faulty methods in singing or speaking, etc.—and abnormal conditions of the digestive apparatus.

Shurley, who divides the subject into many heads, admits that in the greater number of cases chronic laryngitis arises secondarily to acute inflammation or other injury to the larynx. He says it occurs most frequently between the ages of eighteen and fifty years, commonly as a sequel to one of the exanthemata, or as an accompaniment of the change of the voice at puberty, or in old age. Sex and occupation play an important part in the causation, the occupations of the male being much more apt to produce abuse of the voice, and he is also more exposed to the weather, to excesses in the use of tobacco and alcohol, etc. He says that chronic laryngitis may also occur as a direct extension of disease of the nose, naso-pharynx and pharynx, tonsils, or lingual glands. Shurley appears to believe somewhat in heredity, while not quite acknowledging the existence of a catarrhal diathesis which the French (according to Beverley Robinson) believe in. Nephritis and ovarian disease are cited by him as causes, also rheumatism and lithæmia.

Endeavoring to assimilate the various ideas of these six undoubted authorities, besides many other writers whom I might quote, I would say that the chronic form of laryngitis is often the final ending of one or more acute attacks; and also that it is difficult to conceive of any variation from perfect health or perfectly normal habits, which may not cause chronic laryngitis. There are, furthermore, cases which appear to arise from no assignable cause whatever.

Pathology.—If it be admitted, then, that repeated attacks of acute laryngitis eventuate in the chronic form, it is during these acute conditions that hypertrophic changes take place in the mucous membrane of the larynx, these changes varying with the locality. The small-celled infiltration, from whatever cause arising, does not undergo complete absorption and is also associated with proliferation of connective tissue; consequently each recurrent attack increases the formation of new tissue.

The histological manifestations are generally the same in all forms. Although the chronic hypertrophy may be diffuse in all parts of the larynx, yet there will usually be some particular spot where its greatest development will be attained.

In the chronic hypertrophic form the inflammatory changes are found chiefly in the connective tissue beneath the epithelium, being more developed in the vicinity of blood-vessels and the efferent gland ducts. There may also be thickening of the perichondrium and cartilages. There may have been metaplasia of the epithelium—a

change to stratified pavement epithelium, which in some old cases may be composed of from fifteen to twenty layers. The epithelium is infiltrated with leucocytes, most abundantly in those places where the tissue underneath shows great infiltration.

The membrana propria may be thickened and fibrillary. Beneath the statified cylindrical epithelium, the papillæ of the mucosa show proliferation and branching, and may form prominences. The connective tissue of the papillæ is soft, poor in fibres, and shows a marked infiltration with leucocytes. The submucosa is in general much altered, but the inflammatory process varies in intensity in different places. The round-celled infiltration appears at times diffuse, or at others circumscribed in the form of nodules, most conspicuously around the efferent ducts of the glands. It appears hard, compact, markedly fibrillary, containing only a few spindle cells. Some of the cells show hyaline degeneration.

The blood-vessels are in general large and thin-walled, well filled with blood, except where the mucous membrane has undergone fibrous degeneration. The mucous glands may exhibit hyperplasia. The epithelial cells may show a high degree of mucous degeneration. The perichondrium, in the regions corresponding to the most marked alterations of the mucous membrane, may be infiltrated with leucocytes and show hypertrophy of the cartilage.

Symptoms.—Among the most noticeable is a huskiness or want of clearness of the voice, which is realized more in the speaking than in the singing voice. Sometimes the voice may be momentarily cleared by taking food, acid fruit, or a little water, but this relief will be only temporary, and at night particularly the voice will be worse. In singers the range of the voice is diminished. There is sometimes a slight cough, but an inclination to clear the throat by swallowing is almost ever present.

The subjective symptoms are more a sense of fatigue in speaking than absolute pain. I have known of cases in which I have said to a singer, "You are hoarse, your voice must be off"; the reply would be, "Oh, no, I can sing very well"—and, on singing, the greater tension put upon the laryngeal muscles would result in the voice becoming quite clear, but it would lapse again into hoarseness when conversation was resumed. Later on in the course of the disease, cough is a more constant symptom, but implication of the trachea and bronchi may be suspected if expectoration is profuse.

The cause of the hoarseness has been variously stated by different authors, some believing it to be due to drying and want of lubrication of the parts, others to peripheral nerve pressure and also to mechanical interference due to the hyperplasia. This hoarseness may so greatly increase in the later stages that the voice may be entirely lost, and then the effort to produce sound by forcing a large air column through the larynx will be followed by great fatigue, sometimes by an aching pain in the chest or larynx. There may sometimes be quite a lancinating pain in the larynx during respiration and, as the patient expresses it, the air seems to cut as it passes.

Diagnosis.—On laryngoscopic examination the most noticeable symptom is congestion, well marked over the arytenoids, aryepiglottic folds, and ventricular bands, of rather a dusky red but not so high colored on the vocal cords, and giving the impression of slight swelling in the hypertrophic form or the converse in the atrophic. The presence of mucus is uncertain, but it is apt to be of a sticky, ropy, tenacious character, and cannot always be removed with the spray. The edges of the cords appear roughened and sometimes greatly relaxed, or even crescentic in form. In some cases there is the appearance of interarytenoid thickening, which seems to prevent the approximation of the cords and thus produces the hoarseness already referred to. In the ulcerative or hemorrhagic variety, in addition to the swelling and congestion, there may be shallow erosions or excoriations, for morning cough, accompanied by an expectoration of mucus, streaked or tinged with slight traces of blood, is common in chronic laryngitis. In the atrophic form, added to a wasting of the tissues, there is usually a drying of the mucus on the surface, particularly in the commissures. This inspissated mucus will sometimes have to be removed with the cotton-covered applicator, or after spraying with some alkaline solution it may be expelled

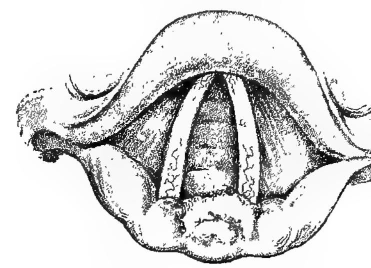

Fig. 3116.—Chronic Laryngitis.

like a cast of the parts; or it may be expelled in smaller pieces which sometimes have the well-known odor of similar crusts in the nasal fossæ.

Course of the Disease and Prognosis.—If the chronic inflammation is confined to the larynx, an uncomplicated case may run along for years without occasioning any great discomfort, and it may after that be relieved or cured by treatment; but the tendency is to spread downward, where it becomes a chronic bronchitis and perhaps in time prepares the way for an implantation of tubercle bacilli either in the bronchi or in the larynx, it being well known that diseased tissue offers the best conditions for receiving these germs. The majority of these cases of laryngitis do not, however, by any means have this gloomy termination.

The great majority of patients with chronic laryngitis are never cured; they may get better for a while, perhaps, during warm weather, but they are never quite cured, and when the cold weather comes the symptoms return; and probably the next season of amelioration will not be for so long a period. And so, after a while, there is no period of ease, and the condition is always just the same.

Treatment.—An immense amount has been written upon the treatment of chronic laryngitis. According to Newcomb and also Shurley both general and local treatment should be pursued. All "bad habits" should be abandoned. If a smoker, the patient should not smoke; if a drinker he should cease drinking. If there is any abdominal, visceral, vesical, or uterine abnormality it should be thoroughly cured first, in order to permit of a cure of the laryngitis. If there is obstruction of the upper air passages, the nose or pharynx, these crooked paths should be made straight, and then, in mild cases, after all this has been done the laryngitis may subside without much local treatment. In cases in which physical and moral reforms are impossible or in which the patient cannot be confined in prison (see Shurley on the treatment of chronic laryngitis), something constitutionally may be accomplished by drugs. Iodine, by reason of its action on the mucous membrane, deservedly holds the first place, and of the forms of iodine the syrup of hydriodic acid is certainly preferable. In my experience the greatest drawback to the use of iodine is the iodine rash, which seems almost always to follow its use except in specific cases. Muriate of ammonia is also of some value. Shurley suggests mineral waters, and Professor Niemeyer's drink of Vichy water and hot milk is at least pleasant. Galvanism is advocated by some, but I have found it quite as useless as in the cases of chronic pharyngitis and anosmia from nasal catarrh.

In the matter of local treatment, topical applications are preferable to sprays, for with these one can touch exactly the points desired, and much stronger medication can be used than when the whole surface is irrigated with a solution. Of course the parts should be previously prepared for these applications by spraying them with a

mild solution of cocaine (3 to 5 per cent.). Nitrate of silver in its varying solutions (5, 10, or 20 grains to the ounce of water) is a very old but very reliable remedy. The glycerite of tannin, or a mixture of iodine and glycerin (ʒ iss. to glycerin ℥ ij.) is efficacious. In the Transactions of the American Laryngological Association (1882, 1888), Dr. J. O. Roe, of Rochester, says, after considering the various systemic conditions which may predispose to chronic laryngitis: "It will be found that local medication is the plan not only more generally successful than all others when the various associated and contributing conditions are duly considered and treated therewith . . . Cases which had not been improved by general medication alone have yielded a ready obedience to the applications of medicaments topically applied to the larynx."

Dr. Charles E. Sajous, under the head of "Treatment of Chronic Laryngitis by Chromic Acid," quoting from Dr. Carlo Labus, of Milan (1880), speaks of the process of flaying the vocal bands or denuding them of their mucous membrane, and of the numerous cures of laryngitis and the accompanying hoarseness thereby obtained. This mode of treatment was also extolled by Massini in 1888, but the procedure was apparently abandoned on account of the harshness of the operation. Sajous mentions the fact that in these chronic cases, during an exacerbation, the edges of the cords are irregular and dentated, and he states that it is in this class of cases that vigorous treatment is required. He hesitates to use the flaying process on account of the liability to hemorrhage, and the solid stick of nitrate of silver or the galvanocautery on account of the tendency to produce hard nodules of scar tissue on the edges of the vocal cords. He advocates first preparing the larynx by applications of resorcin followed by belladonna. A twenty-five-per-cent. solution of cocaine is applied to the larynx at the time of operation, and then a covered probe on which chromic acid has been fused is applied to the vocal cords, but not to their edges. This is repeated at subsequent visits until the whole surface is cauterized.

Trachoma of the Vocal Bands.—(Synonyms: Chorditis nodosa, chorditis tuberosa, singers' nodes, vocal nodules.) The various names applied to this lesion are certainly confusing. Dr. Charles H. Knight, of New York, in a paper on "Vocal Nodules" (Transactions of the American Laryngological Association, 1901) says: "The term 'vocal nodules' has already been applied by Elsberg to certain *anatomical* formations in the larynx, but confusion is not likely to arise since its use in the latter sense has not been generally adopted. The term 'singers' nodules' implies a professional factor by no means always present. A large proportion of these cases in my

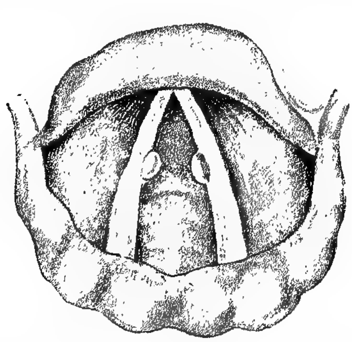

Fig. 3117.—Singers' Nodes. (Copied from a photograph by Dr. T. R. French, of Brooklyn, N. Y.)

experience have been in those who use the voice in singing but little, or not at all. 'Chorditis tuberosa' suggests an inflammatory origin, whereas marked hyperæmia even is rather an exceptional feature. 'Trachoma of the vocal bands' and 'Pachydermia laryngis' are terms used to designate processes histologically allied to vocal nodules, but very different in their clinical aspects."

On the other hand, Dr. Clarence C. Rice, of New York (Transactions of the American Laryngological Association, 1900, and the subsequent discussion), says that under the name "chorditis tuberosa" this pathological condition of the vocal apparatus is of interest to the laryngologist because it occurs frequently in public speakers, singers, and actors. He quotes from Türck, who used the same name: "He says he had noticed four cases of this peculiar inflammation of the vocal bands in singers." Rice subsequently states that out of eight cases observed by him six were in singers; the remaining two cases were in people who used their voices more than in ordinary conversation—one a Hebrew, who read aloud some religious ceremony every week, and the other, the foreman of a large number of laborers, who was in the habit of shouting to his men. The six singers were all sopranos. In the subsequent discussion Dr. Westbrook, of Brooklyn, reported the case of a lady who was not a singer, but was a great talker.

Etiology.—Under the head of "singers' nodes," Dr. Frederick I. Knight, of Boston (Transactions of the American Laryngological Association, 1894) gives such a clear description of this lesion as it has come under his observation that I cannot do better than to quote from his article: "The affection of which I wish to say a few words consists, as I have seen it, of a small ovoid nodule situated on the edge of one or both vocal cords at about the junction of the anterior and middle thirds, and can usually be attributed to extraordinary or improper use of the voice. It has been described as one of the conditions found in chronic laryngitis, and also as trachoma of the vocal cord, and as chorditis tuberosa; it occurs, however, as has been pointed out by Rice, as a primary affection, with or without laryngitis. The cases of Türck presented multiple granulations, not only on the edge but on the upper surface of the cords.* The single nodule on one or both cords, although it may be pathologically the same, constitutes clinically a distinct affection and is, I think, entitled to a separate designation."

My personal experience, and I have had several cases, is that this affection consists of the single or bi-cordal nodule usually situated at the junction of the anterior and middle thirds of one or both vocal cords, and is found in those larynges which have been either overexerted or wrongly used by shouting or singing too high, or in those belonging to persons who have indulged in singing when not knowing how to sing.

Finally, when looking at the causation of this lesion, we must not overlook the fact that it is sometimes associated with tuberculosis, and also that the presence of hypertrophied tissue at the base of the tongue seems to be a cause.

Pathology.—Some confusion exists with regard to the conceptions of the nature of the so-called vocal nodules. Three hypotheses have been brought forward:

1. *Physical, i.e.*, mechanical, friction of the margins of the cords at points determined by swelling of the vocal cords.

2. *Physiological.* The vibrating nodes of the vocal cords, being points of the most violent action, are predisposed to the formation of the nodules.

3. *Anatomical.* The vocal nodules stand in relation to a gland situated at the posterior end of the free portion immediately under the margin of the cord.

The present consideration is limited to those cases which are dependent upon hypertrophy of the epithelium. The swellings are composed of stratified pavement epithelium, ranging in thickness from 10 to 40 μ, due to a considerable increase in the layers of polyhedral and cylindrical cells. At the level of the polyhedral layer the protoplasmic substance is well marked, the nuclei are large, and stain well by carmine. The cells are intimately connected with each other by a protoplasmic substance and prickle cells without the interposition of leucocytes.

* This is evidently a description of pachydermia.

The chorion is composed of fusiform cells with bipolar prolongations, which one may follow over an extent of 60 μ. The deeper layers of the section show a few strands of elastic fibres. There is no actual papillary layer present. The fibro-elastic chorion is thickened and distinctly less vascular than normal. In some cases a process of degeneration and cyst-formation occurs.

Symptoms.—Hoarseness, even aphonia, in singers' nodes comes on very suddenly, following quickly upon the voice strain, and it is accompanied by a good deal of laryngitis of the acute form, and want of tone in the tensors. The edges of the cords look flabby, perhaps each cord will be bicrescentic in outline and at the junction of the horns of each crescent will be seen the little node. In phonation this node strikes its fellow of the opposite cord, or the edge of the cord if there is no fellow; but the edges of the cords do not approximate, and thus the aphonia is produced. Time and vicarious action of the other cord will to some extent modify this aphonia, particularly in singers who, when well trained, have such wonderful control over the action of the larynx.

Prognosis.—The prognosis depends largely upon the ability of the patient to rest the voice, and whether the lesion is a recent one or not. It is like the law of storms: "long foretold, long last—quick coming, soon past."

Treatment.—The most important thing is rest for the voice, and many cases are cited in which the nodules have spontaneously disappeared under complete rest. This, however, is denied by Capart, who says he has never seen the slightest benefit from rest. Charles H. Knight and Holbrook Curtis advocate vocal exercises, or courses of elocution performed in about the following way: "The first point insisted upon is a correct method of breathing. The upper ribs are raised, the chin is depressed, and respiration carried on by the diaphragm and lower ribs; an effort is made to focus tones in the face, producing them, as it is expressed, 'dans le masque.' The word or syllable used is 'Ma,' or 'Man,' the 'M' of course being formed while the lips are closed. The muscles of the pharynx and neck are thus supposed to be completely relaxed and the vocal bands to be in a state of greatest possible tension. A peculiar tickling vibration of the lips against the incisor teeth can be felt during the humming 'm' sound, provided the muscles about the mouth are properly relaxed. Most remarkable results from the practice of these vocal gymnastics are claimed in various laryngeal derangements due to misuse or fatigue of the voice." "Capart divides treatment of vocal nodules into hygienic, medical, and operative. Sprays and insufflations of astringents and antiseptics he looks upon as useless, and chemical caustics like nitrate of silver and chromic acid he discards on account of the risk of their diffusion. Ablation of the growth with a fine delicate forceps, or, if that is impossible, its destruction with the galvano-cautery is recommended. He warns against the so-called punch forceps, lest an excessive amount of tissue be removed and the voice irreparably damaged."

Change of the method of singing may in some instances conduce to a cure. Change of climate is also suggested. Absolute silence, though generally recommended, will be found difficult to enforce. And the difficulty of operating on so small a neoplasm without injuring the surrounding cord must be borne in mind. C. H. Knight saw considerable improvement in one of his cases following the instillation of adrenalin chloride, 1 to 5,000, carried on daily for a period of three weeks. C. C. Rice (discussion of Dr. C. H. Knight's paper, Transactions of the American Laryngological Association, 1901) states that he has had a few cases which have done well under treatment with chromic acid, and he prefers this to the galvano-cautery.

PACHYDERMIA LARYNGIS.—There is one form of pachydermia, of syphilitic origin, which I shall not touch upon, as it will be treated of in connection with syphilitic perichondritis of the larynx. The form with which we have to deal here is probably of inflammatory origin, according to Virchow; or is caused by friction, according to Schrötter. However, it is a form of chronic laryngitis, and is seen in those cases in which laryngitis is either chronic or recurrent in form, and has been present for a long period of time.

Cases which I have seen have been in persons who have found it necessary to use the voice while suffering from acute laryngitis, not necessarily straining the throat, by pitching the voice too high, as in the case of chorditis tuberosa, but merely using the voice when it should have been at rest. The theory of the causation by friction hardly seems tenable, for the reason that the "plaques" and enlargements seldom form on the free edges of the cords, but usually on the aryepiglottic folds, where friction is very slight. This observation as regards location is that held by E. Meyer and P. Bergengrün.

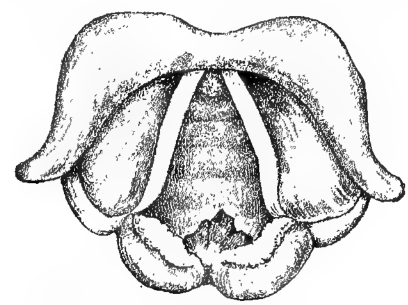

FIG. 3118.—Pachydermia; Central Vegetation with Gray Plaques on Each Side.

On laryngoscopic examination the cords are seen to be thickened and there is a want of approximation in their entire length, a condition which is largely due to the thickening in the posterior commissure, as well as to the irregular growths which may be seen there. These flattened and irregular nodules are not at all of the same size or shape as the singers' nodes (which are small and round like large pinheads), but are more like flattened warts. From these warts as a centre patches of thickened membrane of a grayish-pink color extend outward, and are always raised above the surface of the surrounding mucous membrane. Occasionally these patches are present by themselves and not connected with the warty growths.

Symptoms.—This being a form of chronic laryngitis, the symptoms are necessarily similar, and it is only on laryngeal examination that the lesion will be recognized. Hoarseness, and hoarseness of a most persistent character, is generally observed, and there are great dryness and some little soreness of the throat. There will be exacerbations of the hoarseness, it frequently getting somewhat better, but never disappearing completely.

After persistent efforts to make themselves heard the patients often experience great fatigue.

Cough is generally present to some extent and mucus is frequently expectorated, but the improvement of the voice after this clearing of the throat is never so great as might be expected, the condition differing in this respect from simple laryngitis.

Pathology.—Pachydermia laryngis, histologically considered, is an inflammatory hypertrophy of the connective tissue of the mucosa which subsequently affects the epithelium. This is evident in those places where this process can develop unmodified by external influences. Histologically the epithelium is seen to be thickened and horny in its upper layers, which are formed by flat cells with indistinct nucleus and without nucleolus. Among them there occur layers of cells in which keratohyalin may be encountered. The lowest layers of the epithelium, which are situated upon the connective tissue, are composed of cylindrical cells. Between these and those which contain keratohyalin are layers of polygonal cells with prickle processes and deeply staining nuclei, which correspond to the rete Malpighi of the external skin. These horny alterations occur not only in the vocal cords

and those portions of the larynx which normally have pavement epithelium, but also in other regions covered with columnar epithelium, as, for instance, the ventricular bands or ventricles. In these latter situations we may see a transition from columnar to pavement epithelium.

On the free surface of the vocal cords in pachydermia there occur, in addition to the normal folds, actual papillæ which may penetrate farther into the thickened epithelium than the level of the normal folds. These are particularly well developed in the region of the vocal processes. While the connective tissue thus sends papillæ into the epithelium, the epithelium in turn penetrates the connective tissue with interpapillary prolongations which may be divided into several summits.

The subepithelial layers of the connective tissue exhibit an increase in the number of round cells, particularly in the neighborhood of the glands. The cells may penetrate the cylindrical epithelium of the latter and fill the lumen of the efferent ducts. Keratohyalin is apt to occur together with the formation of papillæ, giving the tissue an epidermoid character.

The origin of the depressions at the summit of the pachydermal swellings on the vocal process is not wholly clear. In cases which have been investigated histologically the depression in the centre of the swelling is seen to correspond exactly to the point of the hyaline cartilaginous process. This latter is hypertrophied connective tissue, which, around the point of the cartilage, is prolonged upward into papillæ that are covered with a thick layer of pavement epithelium forming the margin of the growth in question. Virchow believes that the depression occurs by reason of the closer approximation of the mucous membrane to the point of the cartilage in the centre of the growth than at its periphery. Fraenkel explains it by the mutual pressure exerted by the vocal processes during phonation.

Ulceration is apt to occur in pachydermia in most cases of long duration. It begins in all cases from the surface, and perhaps is initiated by the rubbing of the apposed portions of the mucous membrane on each other. Perichondritis may be observed in association, but its relation to the ulcerative process is not clear. It is possible that some of the cases reported owe the origin of these processes to tuberculous, syphilitic, or typhoid infections. It is possible that both Virchow's and Fraenkel's views are correct.

Prognosis.—This is not hopeful, for there is so much structural change that it seems almost impossible that the larynx should ever return to its normal condition. Whether the *x*-rays may not at some future time reduce these hyperplastic growths, as they have done in cases of sarcoma and papilloma of the larynx, remains to be seen.

Treatment.—In my hands the cautery has had to be used with great caution, for this condition seems prone to take on acute inflammation rapidly, and the possibility of an acute inflammation supervening on the chronic thickening cannot be overlooked.

Astringent applications do some good if they are not too strong and are used after spraying with cocaine. I think perhaps I have obtained the best results from insufflations of protonuclein powder. The employment of this remedy is of course entirely empirical, for there seems to be no reason why a tissue builder should be indicated in a case of exuberant growth.

There have been temporary good results from touching the growth carefully with chromic acid—just a crystal fused on a protected probe. This can be used with more certainty than the galvano-cautery knife.

Thomas Amory De Blois.

LARYNX, DISEASES OF: ARTHRITIS AND ANKYLOSIS OF THE CRICO-ARYTENOID ARTICULATION.—DEFINITION.—Arthritis of the crico-arytenoid articulation is an inflammation of the joint, usually involving the perichondrium and adjoining tissues. Ankylosis is a partial or complete immobility of the joint from the formation of adhesions and the organization of an inflammatory exudate, usually in consequence of a previous arthritis.

ETIOLOGY.—The most frequent cause is perichondritis, the various types of which are described under that name. Quite rarely, "cold" and vocal abuse influence infection. It may be due, in either the acute or the chronic form, to rheumatism, gout, and the condition termed arthritis deformans. It is liable to follow either internal or external traumatism. It may be due to metastasis of the specific infecting organism in typhoid and other fevers, conjoined usually with secondary pyogenic infection, and it may arise by continuity of tissue in phlegmonous laryngitis and diphtheria. The crico-arytenoid joint may become stiff or even ankylosed from prolonged immobility in vocal-cord paralysis. The most frequent of all causes, however, is perichondritis due to syphilis, tuberculosis, or carcinoma.

PATHOLOGY.—In the milder forms of acute idiopathic arthritis ascribed to "cold," vocal abuse, and laryngitis submucosa, and more particularly in the rheumatic types, the serous exudation usually proceeds to resolu-

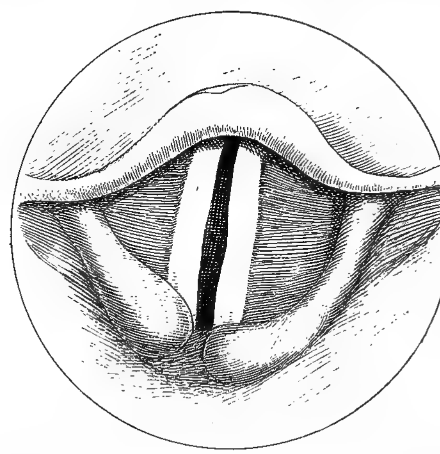

FIG. 3119.—Ankylosis of Right Crico-arytenoid Articulation. (Dr. Casselberry's Case.)

tion and absorption without suppuration, although more or less ankylosis is liable to result, presumably from the formation of adhesions. The infiltration of syphilis may attack directly the cartilages and perichondrium, and tuberculous arthritis analogous to the white swellings of the larger joints is a possibility; but usually in these types, as well as in typhoid fever and septic cases, a secondary infection by pyococci occurs through ulceration of the soft parts, and this results in an abscess, necrosis, and exfoliation. Of course if the joint is involved in the destructive process ankylosis ensues. Œdema, which is a prominent feature of the acute stage, is replaced in the chronic state by a cellular infiltration leading to tumefaction of the overlying parts.

SYMPTOMS.—Acute arthritis will occasion febrile symptoms, hoarseness, and local discomfort. Swallowing is painful, and if there is much œdema or swelling respiration may be seriously obstructed. Chronic ankylosis may be manifested only by impairment of the voice, although if it is double the dyspnœa is liable to be serious, especially during acute exacerbations. The writer has recorded a case of this sort under the name of "arthritis deformans of the larynx."

Laryngeal Image.—The aspect and more pronounced symptoms of arthritis will be found in detail under the title of perichondritis, so that only the appearance presented by the resulting ankylosis, which is of special value in diagnosis, need be here noted. The vocal cord is more often fixed in the cadaveric position (Fig. 3119), in which event on phonation the opposite movable cord will make a supplementary excursion across the median line to meet the fixed cord, producing an oblique distor-

tion of the larynx. On deep inspiration the fixed cord fails to abduct. The voice is weak and hoarse although not necessarily lost. Next in order, the cord is found fixed in or near the median line, when the voice will be but little altered; and quite rarely the cord retains the position of abduction, when the voice is reduced to a whisper. If both sides are involved the cords are not usually symmetrically placed, but if both are near the median line there is serious dyspnœa; if they are not near the median line, there is aphonia. Luxation or displacement of the arytenoid, and absence of this cartilage in consequence of previous exfoliation, distort the image in a corresponding manner.

Diagnosis.—The salient feature in diagnosis is to differentiate ankylosis of the crico-arytenoid joint from paralysis of the vocal cord. Usually in ankylosis there is either acute or remaining chronic tumefaction about the joint, while in paralysis there is none, unless one examines the case of paralysis at a time when the larynx is inflamed from "cold" or efforts to force the voice. In ankylosis without paralysis there is no "falling in" of the affected arytenoid, the sound arytenoid approaching it on phonation but not crossing or displacing it. In ankylosis there is nearly always a slight adductor movement; in complete recurrent paralysis there is none. A history of previous arthritis or its causes, especially typhoid fever or syphilis, is of significance. Apart from these points the diagnosis is based upon the laryngeal image and upon the exclusion of any central or peripheral cause of paralysis, such as syphilitic bulbar disease, tabes, aneurism, carcinoma of the œsophagus or other neoplasms, goitre, toxic neuritis, etc. As paralytic immobility may lead to ankylosis the two may be conjoined. The diagnosis of arthritis is further described under the title of perichondritis.

Prognosis.—In acute arthritis the danger of life from dyspnœa may require a prompt tracheotomy. In typhoid-fever cases the mortality is very high. The prognosis is favorable in traumatic, rheumatic, and syphilitic cases, but there is a liability to ankylosis. Tuberculous arthritis is of grave import. True ankylosis is permanent. The outcome of "false ankylosis," or restricted mobility from adhesions external to the joint, will depend upon the feasibility of dividing the adhesions.

Treatment.—In rheumatic and syphilitic arthritis and in cases of doubtful origin the patient should receive the specific medication which is appropriate to the constitutional disease. Cold, in the form of ice swallowed and a Leiter coil spread over the larynx externally, is useful in the very early stage of acute arthritis. Alkaline and emollient sprays serve to clear the throat of mucus. Cocaine in two- to four-per-cent. solution is of value in causing temporary retraction of the œdematous swelling, but its powers are limited. Chronic ankylosis is not amenable to treatment unless there is stenosis of the larynx, when forcible or gradual dilatation by intubation tubes and bougies may be indicated.

W. E. Casselberry.

LARYNX, DISEASES OF: CONGENITAL MALFORMATIONS.—Congenital malformations of the larynx may be classed under four heads, namely: (1) Absence; (2) excessive development; (3) cleft; and (4) deviations of form and situation.

Complete absence of the larynx occurs in the rare cases of monsters in which the head and the thorax are wanting, and which are known as acephali, amorphi, and acardiaci. A complete absence of the larynx has also been noted in a monster described as "inclusio fœtalis peritonei."

Partial absence may consist either in a general atrophy of the organ, or in the absence of one or more of the cartilages. Thus, in some instances there is a complete absence of the epiglottis; in others it is represented by a high rudimentary ridge; while in one case it is described as merely a fold of the mucous membrane. The thyroid, cricoid, and arytenoid cartilages may be absent. They also may be rudimentarily developed, either altogether as regards one of them, or only in certain parts of each. For instance, the thyroid may lack one or both superior cornua. Again, the thyroid may be cleft, and the two plates may be connected together by a cartilaginous band. The same abnormality has been observed in the cricoid, in some instances to such an extent that the connecting band may take the place of the original cricoid, and thus cause it to resemble a tracheal cartilage. Finally, the whole larynx may be abnormally small, as seen in the male when there is congenital atrophy of the testicle, or when castration has been practised early in life. In such cases it resembles the larynx of the female or of a child.

Hypertrophy.—This division may be made to include the double formation of the larynx observed in the case of double monsters, namely, in the so-called thoracodidymis and also in the dihypogastricus varieties. These possess two larynges, but only one pharynx and one œsophagus. A cartilaginous plate is sometimes found interposed anteriorly between the wings of the thyroid.

Supernumerary cartilages are occasionally found on the outer corner of the cricoid cartilage. They are analogous to sesamoid bones. Supernumerary folds of the mucous membrane are sometimes seen, as, for instance, a transverse fold below the epiglottis.

The laryngeal ventricle may be abnormally wide and deep, and thus render the part more liable to eversion, to the lodgment of a foreign body, or to other accident. The anterior section of the glottic space may be more or less occluded by a web-like formation, of considerable density, and somewhat resembling an imperforate hymen.

Cleft Formation.—There is no such thing, it is said, as a congenital laryngeal fistula of the neck. A case of cleft epiglottis has been reported by French.

Congenital deviations of form and situation of the larynx are rare, and occur only in connection with congenital malformations of the most marked type, such as hemicephalus, and double spina bifida of the upper portion of the spine, and in extreme lordosis of the cervical vertebræ. In these the whole larynx is depressed and moved backward to the level of the upper dorsal vertebræ. The thyroid is placed very obliquely, by which the inferior diameter of the larynx is markedly increased, while the cricoid is situated much deeper, in proportion to the thyroid, and thereby the true and the false vocal cords are abnormally lengthened. The sinus pyriformis on each side is obliterated.

Slight asymmetry of the larynx, as to position and form, is not infrequently met with.

D. Bryson Delavan.

LARYNX, DISEASES OF: ERYSIPELAS.—Erysipelas of the mucous membrane of the pharynx and larynx is, pathologically, similar to the same malady when situated on the skin. It occurs either primarily or by extension from the face along the mucous tracts of the mouth, nose, or ear. Its causes are the same as those which give rise to it when situated upon the external parts of the body, although it has been most often observed in the course of general epidemics of the disease. Of eighteen patients seen by Cornil, in whom the pharynx was affected, fifteen were under the age of thirty, and twelve were females. Upon inspection of the pharynx, the appearance of the mucous membrane, when affected with erysipelas, differs considerably according to the form of the disease which is present; the local phenomena are generally very different from those of simple inflammation, but sometimes cannot be distinguished from it.

Cornil makes three divisions of the malady, viz.: (1) Erysipelas with simple redness; (2) erysipelas with phlyctenulæ; and (3) erysipelas terminating in gangrene. Erysipelas most commonly reaches the larynx from the pharynx, but the former organ may be primarily affected while the pharynx remains healthy. The disease may extend still farther down the respiratory tract, and become associated with pulmonary congestion and œdema.

In cases which come under the first division the diagnosis must remain doubtful, except when the throat lesion is accompanied by manifestations upon the skin.

Erysipelas of the head and neck is often accompanied by more or less congestion of the mucous membrane of the larynx. The symptoms are dysphagia, hoarseness or loss of voice, and pain, increased on pressure from without. Sometimes the disease is much more active, and may result in acute œdema, tending rapidly to a fatal termination. It is believed by some that the so-called primary œdema of the larynx, or phlegmonous laryngitis, corresponds clinically to a localization of erysipelas in the larynx, and that many cases reputed as primary œdema of the larynx are in reality erysipelas. The two affections seem at least to be closely allied.

As to the *prognosis*, the dictum of Hippocrates—namely, "When erysipelas extends from within outward it is a favorable symptom, but when it removes to the internal surfaces it is a deadly one"—has been confirmed by modern observation. In nine cases analyzed by Cornil, in which the face was first attacked, seven deaths occurred; whereas in nine other instances in which the enanthem preceded the skin eruption, seven recoveries took place. Mackenzie saw but four cases in the whole course of his practice.

The *treatment* must be both local and constitutional. The latter should be guided by the general principles which govern the management of the disease in other parts of the body.

As to local treatment, the application of cold to the throat, by allowing cracked ice to dissolve in the mouth, should be practised as long as there is any hope of checking the inflammation. Hypodermatic injection of pilocarpine, if given early, may abort the attack, and mild alkaline sprays, with a small amount of alcohol, have an excellent effect. A solution of morphine applied in the form of spray is recommended by Mackenzie. Care must be observed lest the patient be unintentionally narcotized. Should the disease progress and tumefaction of the mucous membrane of the larynx take place, the conditions become similar to those found in acute œdema of the larynx. (*Vide* also article on *Acute Inflammation of the Larynx.*)

D. Bryson Delavan.

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LARYNX, DISEASES OF: FOREIGN BODIES. See *Air Passages, etc.*

LARYNX, DISEASES OF: FRACTURES AND DISLOCATIONS.—These injuries, although rare, may occur from several causes, namely, violent manual compression, falls, accidents with machines, rolling vehicles, hanging, etc. Of fifty-two cases collected by Hénocque, the thyroid alone was fractured in twenty-three, the cricoid alone in seven, both of these cartilages in seven, while in the rest the hyoid bone, larynx, and trachea were all involved in a common injury. A direct blow upon the larynx may produce a contusion of the soft parts, but can hardly result in fracture, unless the organ is supported to some extent upon the spinal column. Ossification of the cartilages will necessarily render them more liable to injury.

The *symptoms* are pain and tenderness, dyspnœa, expectoration of bloody mucus, and cough, with, sometimes, emphysema of the neighboring areolar tissue. Crepitation and, occasionally, overriding of the fractured edges may also be felt. These symptoms are sometimes so slight as to be hardly recognizable, the patient making a rapid recovery. As a rule they are severe from the first or gradually become so from the development of endolaryngeal extravasation, œdema, or the displacement of fractured parts. Any of these things may cause death by asphyxia. Later, the danger is from abscess, necrosis, and cicatricial stenosis of the larynx. The latter may necessitate the permanent wearing of a tracheal cannula.

The *prognosis* is very grave, especially in fracture of the cricoid; and, unless the symptoms are not urgent, tracheotomy should be performed at once, or intubation of the larynx may be resorted to, with the same object in view.

Should the cartilages be much crushed, Wagner, having done tracheotomy and inserted a tampon cannula, divides the larynx in the median line, separates the thyroid, asepticizes the wound, replaces or removes the fragments of cartilage and packs the cavity of the larynx with iodoform gauze. In extreme cases, extirpation of the larynx or resection may have a future. Panas advises that in some cases the fragments be kept in place, and the patency of the laryngeal canal preserved by the introduction of a small, hollow, india-rubber plug into the larynx from the tracheal opening, and by its subsequent inflation. Leeches to the neck, and ice, both externally and internally, will sometimes prove of service.

Intralaryngeal *dislocations* of the larynx are extremely rare. They are generally of the arytenoids and due to cicatricial contraction.

Fracture of the Trachea, a rare injury, is sometimes associated with that of the larynx. As the fracture occurs in the cervical region the edges of the lesion are apt to be inverted and to cause obstruction. It is sometimes found at the bifurcation. The symptoms are dyspnœa, extravasation, and emphysema, with pain on pressure over the seat of the fracture. The prognosis is bad. The patient should be kept completely quiet and, if dyspnœa appear, tracheotomy should be performed and a cannula long enough to reach below the obstruction should be inserted.

D. Bryson Delavan.

LARYNX, DISEASES OF: GENERAL DIAGNOSIS.—At various times in the first half of the nineteenth century more or less successful attempts were made to see the larynx by means of mirrors placed in the back of the mouth. Bozzini, in 1807, by the use of a cylinder containing an inclined mirror at its further end was able to get a partial view of the larynx. But his idea was rather to demonstrate the possibility of lighting up the different cavities of the body than to study the appearance of the larynx in health or disease. Babington (1829), Liston (1840), and Avery (1844) tried various methods of illuminating the larynx. But it is to Manuel Garcia, a singing teacher of London, that the credit should be given of first practically showing in what way the larynx could be satisfactorily examined. In 1855 he published a work on "Physiological Observations on the Human Voice." These were based on examinations of the larynx, usually his own, by the use of a warmed mirror held against the uvula and soft palate, illumination being derived from the sunlight. The object of his paper and experiments was to inquire into the movements of the vocal cords and the action of the larynx in the production of the voice, and not to discover a method for clinical diagnosis in laryngeal disease. He was followed by Tuerck, of Vienna, who used similar mirrors and sunlight, but was interested in applying the method to the discovery and study of pathological changes in the larynx. Owing to the uncertainty of the sunlight in winter, he seems not to have been very enthusiastic on the subject until after the appearance of Czermak on the field in 1857. The latter, while using the throat mirrors of Tuerck, by advocating artificial light and a concave perforated mirror worn over the examiner's eyes for reflecting the light on to the small mirror held against the soft palate, succeeded in giving a great impulse to the study and knowledge of diseases of the larynx. The rival claims of the two men brought about a widespread discussion of the value of the new method, which has continued to be of the greatest service and has not been changed in any important respect in subsequent years.

The name *laryngoscope* is given to the small, plane mirror placed in the mouth, but the frontal, reflecting head mirror is such an essential aid that the two together are entitled to receive the name. In the time of Czermak round, square, oval and other variously-shaped glass mirrors, as well as those made of polished metal, were

used for examining the throat, but for many years circular mirrors have superseded all others.

For examination of the larynx a strong light is needed, and if the sun were always to be relied upon, it would be of the greatest value, for it gives a degree and kind of light which brings out the color and character of the tissues to a remarkable extent. But, as a matter of fact, we are compelled to use artificial light in most instances. Gas is generally used, and the addition of a Welsbach burner increases its brilliancy and gives it a white color favorable for inspection of the parts.

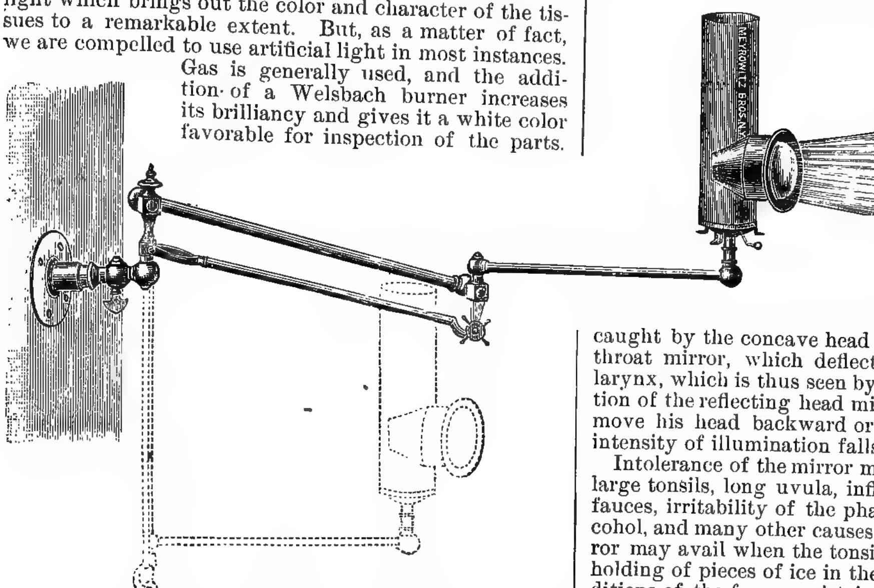

FIG. 3120.—Convenient Form of Gas Bracket for Use in Making Laryngoscopic Examinations.

The electric light has many theoretical advantages, but it is not considered by most laryngologists the equal of gas. In the form of a small electric lamp, called a *photophore*, it is sometimes worn on the forehead. By means of a condensing lens the rays of light are concentrated and can be thrown directly upon the throat mirror, thus enabling the lamp, usually placed by the side of the patient's head, to be dispensed with. The oxyhydrogen light is used to a very limited extent.

To increase the illumination by oil, gas, etc., the rays of light are concentrated by a plano-convex lens placed in front of the flame, this lens serving to throw out toward the examiner a bundle of brilliant, parallel rays. A dark chimney holding the lens shuts off the divergent rays and makes the light coming through the lens all the more effective. It is advisable to have the part of the room where the examining lamp is, fairly dark. A bracket with a movable arm allows a proper regulation of the height and position of the light, which should be on the right side of the patient, on a level with his ear and rather less than a foot from his head (Fig. 3120).

For throwing the light into the throat, a concave reflecting mirror with a central perforation is worn over the eye and held in place by a head-band. This mirror usually has a diameter of about three and one-half inches, and a focal length of from ten to twelve inches.

For the throat, a round mirror with a diameter of about three-quarters of an inch is used. For narrow throats, or where the tonsils are large, and in young persons, smaller sizes may be necessary, and in large, well-trained throats it may be possible to use a glass as large as a silver dollar. The shank should be stiff enough not to bend when the mirror is pushed against the palate and the mirror is attached to it at an angle of 120°. The handle should be of sufficient length to be grasped firmly in the hand, and it is to be held like a pencil. Before it is put into the mouth, the glass side of the mirror should be held over the flame until all moisture is gone from its surface, otherwise it would become clouded when introduced into the mouth. The back of the mirror should always be tested on the hand, after heating, to insure its not being too hot (Fig. 3121).

When the patient is properly seated near the lamp, the examiner sits on a stool or chair opposite him and takes the previously warmed mirror in his right hand. The patient is told to tilt his head backward and protrude his tongue, which the examiner grasps with a napkin in the left hand. The mirror is then passed, with its glass side downward and parallel with the dorsum of the tongue, until it reaches the uvula and soft palate, which it carries upward and backward until it almost or quite touches the pharynx, the shank being then carried to the commissure of the mouth. The rays of light sent from the lamp are caught by the concave head mirror and thrown upon the throat mirror, which deflects them downward into the larynx, which is thus seen by the eye behind the perforation of the reflecting head mirror. The examiner should move his head backward or forward until the greatest intensity of illumination falls on the throat mirror.

Intolerance of the mirror may occur and may be due to large tonsils, long uvula, inflammatory conditions of the fauces, irritability of the pharynx or stomach, use of alcohol, and many other causes. The use of a smaller mirror may avail when the tonsils and uvula are large; the holding of pieces of ice in the mouth where irritable conditions of the fauces exist is a decided help. The most efficacious remedy is a solution of cocaine painted on the pharynx and soft palate. In most cases, however, patience and a little manœuvring will result in a satisfactory view of the larynx. If the tongue is short and thick, it may be impossible to pull it far enough forward to gain room enough for the mirror, in which case we can make use of the tongue depressor and pull forward the base of the tongue sufficiently to allow space for the mirror. This procedure is often of advantage also when the epiglottis bends backward.

The image seen on the mirror shows the posterior part of the larynx on the lower part of the mirror, while the base of the tongue, the epiglottis, and the anterior part

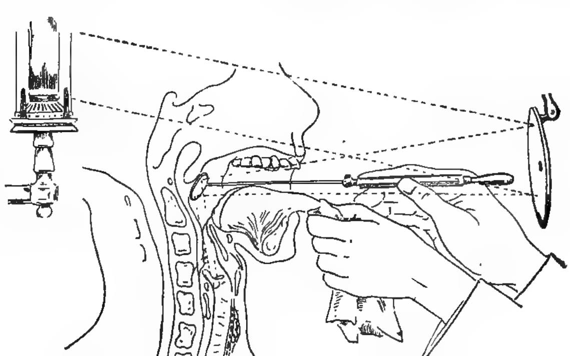

FIG. 3121.—Shows Manner of Holding Tongue and Mirror.

of the larynx are at the top of the glass. The right side of the larynx is on the side of the mirror opposite the examiner's left eye and the left side is opposite the examiner's right eye, just as in the ordinary hand glass.

The epiglottis has a yellowish-red color and varies in shape and position, sometimes being quite erect and at other times quite pendulous, forming an obstacle to a view behind it. Various hooks, forceps, and probes were formerly used to lift up the epiglottis, but they usually make matters worse. If the patient is asked to take a quick, deep inspiration and say the vowel short *e* (like *e*

in met), after a little practice the epiglottis is generally raised enough to permit a view of the cords. The direction, which is usually given, to say ah! in expiration is faulty in that it does not serve to lift up the epiglottis.

The structures in the lower part of the mirror are the aryepiglottic folds and the interarytenoid space, impor-

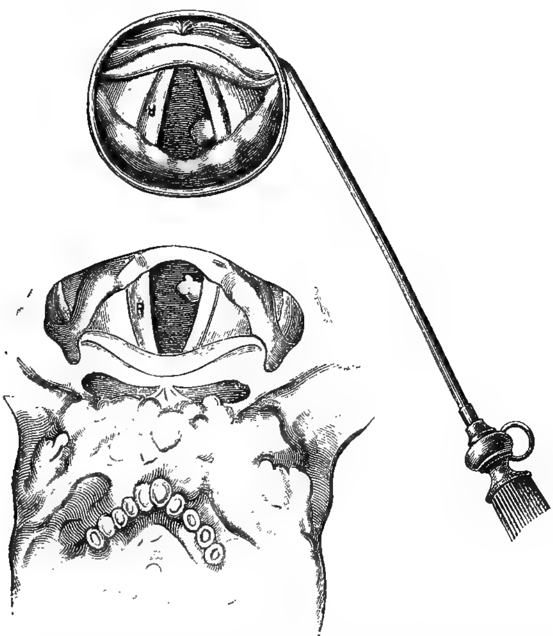

FIG. 3122.—Shows Inversion of the Parts in the Laryngoscopic Image.

tant regions on account of their being the usual seat of lesions in tuberculous laryngitis. These folds start near the median line and extend upward and outward to the sides of the epiglottis. The small rounded projections in their upper surfaces are the cartilages of Wrisberg and Santorini. The vocal cords are seen as white bands which extend from the inner angle of the thyroid cartilage near the top of the mirror to the vocal processes of the arytenoids. In phonation the cords are parallel, their inner edges in contact. In respiration they resemble an inverted letter V. Even in health the cords are not al-

FIG. 3123.—Reflected Image of the Larynx. (Farlow.)

ways white, but are often reddish, so that a diagnosis of congestion or inflammation should not be made from the mere fact that the cords are not white. A very important point in reference to the movements of the cords is not merely whether they come together in phonation, but also whether they separate equally and to the proper extent on the two sides in respiration. Failure to recognize this has caused many cases of paralysis of the recurrent nerve to be overlooked.

Occasionally the larynx is not symmetrically placed in the neck, or it may be pushed to one side by an enlarged thyroid or other tumor, in which case the chink between the vocal cords is oblique in the mirror and not antero-posterior in the middle line of the neck. At the outer edge of the cords are the ventricles, which usually are not very evident, but in atrophic conditions and often in debilitated persons are seen as darkish depressions more marked near the anterior ends of the cords. Just outside the ventricles are the false cords, or ventricular bands, which are red folds of mucous membrane and muscular tissue and not white, fibrous cords. In very forcible closure of the glottis and in some pathological conditions, these bands may come together in the median line in phonation and hide the true cords. Between the aryepiglottic folds and the sides of the throat are the pyriform sinuses, through the floor of which the superior cornua of the thyroid cartilages may sometimes be seen as whitish lines. Between and below the cords are seen the rings of the anterior wall of the trachea, often as

FIG. 3124.—Kilian's Method of Examining the Posterior Wall of the Larynx.

many as five or six, and, in very favorable cases, a view of the bifurcation can be made out and even a little of the left bronchus.

In the usual method of examining the larynx, as described above, the patient's head is tilted backward and the throat mirror reflects the image of the anterior tracheal wall. In order to see the posterior wall and the arytenoid region from a different point of view, we make use of what is called the Kilian method, advocated by Dr. G. Kilian, of Freiburg. The patient stands and bends his head forward, the chin pressed against the chest. The examiner kneels in front of him, grasps the tongue and presses the throat mirror directly upward against the soft palate. The dark chimney with its lens should be removed from the lamp. In favorable cases, a most satisfactory view is thus obtained of the inner and

under surface of the arytenoids and especially of the posterior wall of the trachea, possibly way down to the bifurcation. The absence of the tracheal rings makes a picture quite unlike the usual laryngeal image (Fig. 3124).

In patients wearing tracheotomy tubes a small mirror may be introduced through the opening of the tube, and the subglottic region and the under surface of the cords can then be distinctly seen.

Transillumination was advocated by Voltolini, but at the present time not much use is made of it. In a darkened room an electric lamp enclosed in a hollow tube open at the end is placed against the neck in the laryngeal region. The throat mirror is placed against the soft palate in the usual way, but no head mirror is used, the illumination coming through the skin, larynx, and tissues of the throat to the mirror in the mouth. It was expected that the light thus traversing the laryngeal structures would bring out very clearly differences in density, thickenings, neoplasms, etc., and prove of great value in deep-seated affections, but, as a matter of fact, it plays no important part in laryngeal diagnosis.

Under the designation of autoscopy, Kirstein has called attention to a method of examining the larynx directly without the use of the throat mirror. He uses a stiff tongue depressor bent at the end so as to fit into the fossa in front of the epiglottis, by means of which the whole base of the tongue and the epiglottis can be dragged upward and forward, making more room between them and the pharynx. The head mirror worn over the eye throws a strong light down through the space thus opened up in the lower pharynx, and in suitable cases the arytenoids and the posterior part of the larynx can be seen directly, and in exceptional cases even the anterior part has been visible. Kirstein's first tongue depressors were rather complicated, but later he has made use of simpler forms.

Escat, of Toulouse, has devised a forked tongue depressor for use in the glosso-epiglottic fossa for dragging the tongue forward so as to permit a view behind the epiglottis. It is at times possible in children to obtain a fleeting view of the larynx by hooking the tongue forward with the finger passed down to the base of the tongue and then introducing a small throat mirror. As the base of the tongue is a sensitive region, chloroform has been used as an aid in these examinations. Ether causes such an accumulation of mucus in the throat that it is of but little assistance, unless it has been preceded by the administration of atropine.

Tobold describes the case of a lady who, without anything in her mouth, could so depress the base of her tongue that he was able to see her larynx very clearly.

The *x*-ray has been used principally for the discovery and location of foreign bodies in the larynx and has proved of great value in many instances.

The base of the tongue, the epiglottis, and the arytenoids can be reached by the finger, and œdema, infiltration, and neoplasms can sometimes be diagnosed in this way when it is not possible to introduce a mirror.

The laryngeal probe serves to determine the mobility and consistency of structures and to test the sensibility of the lower pharynx and larynx and the condition of the superior laryngeal nerve. *John W. Farlow.*

LARYNX, DISEASES OF: LARYNGECTOMY.—Resection or Extirpation of the Larynx, with Artificial Substitutes.—The history of this operation, like that of numerous other so-called modern operations, shows that it was conceived of some time before being put into actual execution; that an occasional experiment served to demonstrate gradually the possibility of its success; and that, finally, a careful experimental study of its technique led to its trial upon the human subject. In 1829 Albers made some experiments upon dogs to learn, if possible, the exact part played by the larynx in the act of respiration. He opened the trachea and part of the thyroid, and in two dogs removed the entire larynx; the first of these two died of hemorrhage, the second lived nine days and died of starvation. Albers seems to have drawn no special inferences as to the feasibility of thus operating upon man. Von Langenbeck, in 1854, made public mention of the fact that he was prepared to make trial of extirpation upon a patient in his clinic, and he even gave a general description of what he intended to do, but the patient declined operative help. Foulis states that in 1856 Köberle spoke of the propriety of partial and total operations of this nature; and that in 1866 Watson, of Edinburgh, operated upon and lost a patient. The same plan seems to have suggested itself to Hueter, in 1870, who saw an otherwise healthy patient die of cancer of the larynx. His idea was to make a preliminary tracheotomy, and then, after extirpating the growth, to sew the mucous membrane of the pharynx to the skin, in order to make a permanent fistula for purposes of feeding.

But the greatest credit should be ascribed to Czerny, now of Heidelberg, who, in 1870, undertook a systematic investigation of the subject. He was the first completely to demonstrate that not only was it possible to remove the entire larynx from dogs, but that the operation was practicable on man; and he even laid down rules for its performance. He, moreover, showed that when a T-shaped tube was introduced properly, a certain capability of speech might be expected. Such tubes he constructed for some of his dogs, and these tubes were the rude and simple precursors of the elegant models of to-day.

Three years later, Billroth found opportunity, in his Vienna clinic, to make the first attempt upon a living patient. This patient had already undergone a laryngotomy for cancer, which had returned in four weeks and involved all the interior of the larynx. The operation was a brilliant success, and the patient in due time was supplied with an artificial substitute by Gussenbauer, who has displayed conspicuous ingenuity in his mechanical devices for this purpose. The fact that the patient died a year later from cancer of the cervical glands in no wise detracts from the success of the operation as such. The practicability of this extreme measure having received this brilliant demonstration, other surgeons were not slow to resort to it; and Billroth was quickly followed by Heine, Mass, Schmidt, Schönborn, and numerous others.

Indications.—The principal indication for this extremely radical operation is obviously the presence of a malignant tumor which cannot be thoroughly removed by other methods, or which, after previous milder operative attacks, shows a disposition to return. The larynx, however, has been removed for other causes besides the presence of such tumors; it has been removed on account of destruction of its identity from cicatricial stenosis, for lupus, and for intractable perichondritis followed by necrosis; and one may, at least, imagine a case of primary tuberculosis of the larynx in which, if the diagnosis could be made early enough, resection would be justifiable. Indeed, in one case a tuberculous larynx was removed, having been considered to be cancerous; the patient recovered from the operation to die months later of phthisis.

Of course those general principles which obtain concerning the earliest possible removal of malignant growths elsewhere apply with equal force here, and the rule should always be, "the earlier the better." Extreme exhaustion would, in all cases, be a contraindication; so would be the hemorrhagic diathesis and the dissemination of the growth beyond the laryngeal confines, although in several cases more than the larynx has been removed. Thus Langenbeck, in one case, did not hesitate to remove along with it a number of enlarged submaxillary glands, the hyoid bone, and base of the tongue, along with a part of the pharynx and of the œsophagus; he was compelled to tie both external carotids, as well as both linguals, external maxillaries, and superior thyroids. The patient made an excellent recovery, but died some months later from a return of the disease.

Indeed, one may say that the proportionate gravity of this always grave operation depends in largest measure upon the general condition of the patient. Nevertheless, its results have been so conspicuously successful in other-

wise absolutely hopeless cases, that one need never hesitate to advise it when the general condition outside of the larynx is favorable.

The Operation.—The larynx may be removed in whole or in part; in other words, the resection may be complete or partial. We shall give in this place rather a general idea of the former, feeling that any one contemplating its actual performance would desire to refer to the special literature of the subject.

It has happened in many cases that the exigencies of the condition present have called for a tracheotomy, which has thus been made a preliminary to the more radical extirpation. Thus the question has been raised whether preliminary tracheotomy is not always advisable. Of course, if it have been already made, the question is at once settled, but when the matter can be taken under advisement the writer would be adverse to it, and on these grounds: when undertaken a few days previously, it leaves a certain amount of disturbance and adhesive inflammation, which may complicate subsequent dissection; whereas, if left till the extirpation, it can just as well be merged into and become a part of the latter. The surgeon must, however, be prepared to perform it instantly in case of impending suffocation.

The preliminary skin incision should be a long one, down even to the sternum. By making this long incision one may be spared the necessity for making others at right angles; it is also in the line of safety, and healing takes place much more satisfactorily. From the level of the hyoid bone to a point below the larynx this incision should be deepened, until the entire respiratory tract is exposed, and the deep fascia covering the same divided. Now the cutting edge should be replaced by the handle of the scalpel, or, better still, by a reasonably sharp periosteum elevator, by means of which all the lateral attachments of the laryngeal muscles are separated. Any small spouting vessel must be caught in the hæmostatic forceps; any one of sufficient size to call for it must be ligated twice and divided between the ligatures. The isthmus of the thyroid must also be treated in this way. By this process the larynx is freed anteriorly and laterally. To free it and the upper rings of the trachea, if any are to be removed, from the œsophagus, is perhaps the most difficult part of the operation. This must be done with extreme care. It must be remembered that the anterior wall of the œsophagus commences at the level of the cricoid cartilage.

After the larynx has thus been loosened from all lateral and posterior attachments, the thyro-hyoid membrane exposed, and the hemorrhage all checked, the operator is ready to begin its removal. There has been considerable discussion as to whether it is better to do this from above or from below. The writer's preference, based upon his own experience, is for the latter. It is perhaps a little the more abrupt, but it provides for the proper care of the trachea at once, and the operator may proceed to complete his work with less haste. The height at which division shall be made being first decided on, whether just below the cricoid, or between some of the upper tracheal rings, as circumstances may dictate, the section is quickly made. The portion above being already loose, may be quickly lifted out of the way, and a tracheal cannula, arranged to suit the operator, may be rapidly inserted; through this, for the rest of the operation, the anæsthetic is administered. A rubber tube large enough to fit into it may be inserted; the outer end of the tube may then be slipped over a small funnel containing gauze upon which the chloroform is thereafter dropped. Everything having been so cared for as to prevent entrance of blood into the trachea, complete removal is now effected. The matter of removal of the epiglottis, if not already settled upon, must now be quickly decided. If diseased, it must of course be removed; but when it is healthy one may easily waver in opinion. Here again the writer advises its removal, since in actual experience he has had cause to regret having left it. It has in many instances been found a detriment rather than an advantage. The thyro-hyoid membrane and also the folds connecting the epiglottis with parts above, as well as any remaining connections, should now be divided, and the diseased mass lifted out.

After this the surrounding tissues should be subjected to a careful examination, and if any are found to be diseased they should be extirpated. Thus, a part of the hyoid bone, base of the tongue, lateral pharyngeal wall, œsophagus, or thyroid, or some of the cervical or other lymph nodes, may, if clearly diseased or even if simply enlarged, be conveniently dissected out without much difficulty. Despite all this cutting the hemorrhage is not likely to be severe, and so long as blood is kept out of the trachea no great difficulty is met with.

After the completion of the excision a formidably large wound is left, whose most conspicuous features are the large pharyngeal opening, the upper gaping end of the œsophagus, and the divided trachea. It is necessary first to prevent the trachea from retracting, as it naturally tends to do, by suturing it to the margins of the wound; three silk or silkworm-gut sutures suffice for this. The upper end of the œsophagus is then brought up to the hyoid bone and held there by silk sutures, if possible. It is now rarely the practice to retain the trachea tube; the trachea being united to the skin as described above, access to it from the pharynx is shut off by the attachment of the œsophageal margin to the body of the hyoid. In this way leakage into it from above is prevented. The large wound is now closed with sutures and suitably drained, and dressings are applied above and below the tracheal opening.

After-Care.—The requisite after-care is much the same, so far as surroundings are concerned, as in a case of tracheotomy. The air of the room should be kept moist, and at a temperature not much below 80° F.

The patient is placed in the Trendelenburg position, as after intubation, the foot of the bed being raised to a height of from eighteen to twenty-four inches. In this position he may be fed after from twenty-four to thirty-six hours. At the expiration of from seventy-two to ninety hours his feet may be lowered and his head raised, and by the fourth day he may sit up. Until he can swallow food without much difficulty he may be fed by the rectum.

With a wound thus closed the use of an artificial larynx is not contemplated and the tracheal opening remains. Experience has shown that patients learn to retain air enough within the oropharynx and parts below to whisper plainly or even to speak in an ordinary tone of voice. If desired later, the anterior wall of the hyo-œsophageal opening may be perforated to permit the introduction of some form of artificial larynx.

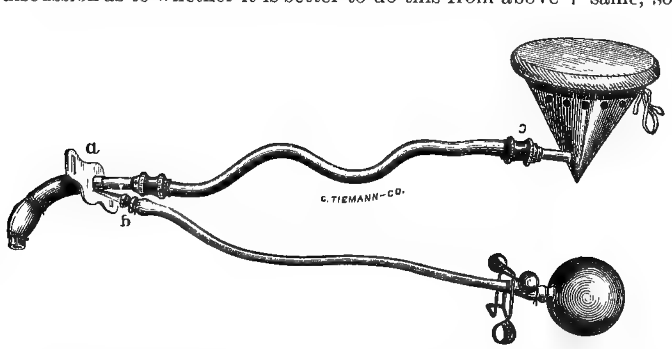

Fig. 3125.—Trendelenburg's Cannula. Easily supplanted by the rubber tube and glass funnel above described.

The Artificial Larynx.—This most ingenious instrument owes its present perfection more to the genius of Gussenbauer, of Vienna, than to any other individual, though it has been variously modified or adapted to spe-

cial cases by different surgeons. The model of the Gussenbauer apparatus, as the writer had it from him in 1882, is shown below in Fig. 1326.

It consists of a tracheal tube of large size (*A*) with lobster-tailed rings at its lower end permitting a slight motion, corresponding to the natural flexibility of the trachea. Through its front plate, and through an opening on its upper curvature, passes a second or pharyngeal tube (*B*), also made flexible (or not, according to the case), with an opening on its lower curved surface so placed that a stream of air may play freely through both tubes, even though the external outlet be closed. The upper end of the pharyngeal tube lodges behind and below the epiglottis, if this have been left *in situ*,

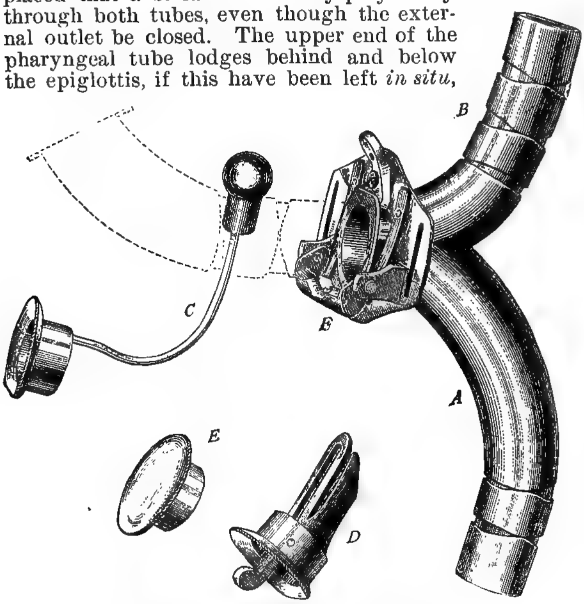

FIG. 3126.—Gussenbauer's Artificial Larynx.

or behind and below the base of the tongue, as the case may be. Around it the œsophagus granulates and closes, so that after the healing process is complete the only passage from the pharynx into the larynx is by way of the metal tube. In order that fluids and solids may not pass through this, an obturator (*C*) is provided, which is passed through the external opening and up through the tube, so that its rounded upper end plugs the upper end of the pharyngeal opening, thus preventing passage of anything into the trachea. But since this would also shut off air, the obturator is attached below, not to a solid plug, but to a ring, as seen, which fits accurately into the external opening of the instrument, and through it the patient breathes so long as this plug is worn. Except at meal-times the simple stopper (*E*) is worn, so that the patient breathes through the nose and mouth. After a time, by an instinctive education of the pharyngeal and buccal muscles, the upper end of the tube is protected during the process of deglutition, and patients wearing these instruments learn to swallow readily without the assistance of the obturator.

The feature of greatest interest about this apparatus is the vocal part. It will be remembered that the vocal cords have nothing to do with articulation, which is all performed above the larynx; they furnish only tone or sound. Possibility of articulation, then, not being interfered with, we have only to find a substitute for the vibrating cords. In the simple mechanism shown at *D* we have such a substitute—namely, a metallic reed, like a melodeon reed, playing freely in a movable slotted bar, and fitted inside of a stopper. This movable bar carrying the reed has an external lever, by means of which the wearer is enabled, with a touch of his finger, to throw it into or out of the air current, and thus, as it were, voluntarily to open or close his glottis. Placing this part of the instrument *in situ*, and throwing the reed into the air current, the metal strip vibrates as it does in the jew's harp, and the sound thus produced is converted, by the articulating parts above, into something more than a whisper—*into distinct speech.* To be sure, the voice is now a monotone, but it is nevertheless a true spoken voice.

Various modifications of this apparatus have been devised by different surgeons to meet the indications in individual cases.

Patients display very different degrees of toleration of these instruments. Some find them excessively inconvenient, others cannot use the reed, and still others wear them continually without much discomfort. A patient of Gussenbauer's, who was known to the writer, wore his apparatus without apparent incovenience; he was almost continually in the saddle as a riding-master, and still kept up his reputation as the best rider in Bohemia.

RESULTS.—The modified operation, as here described, affords, considering its severity, a usually satisfactory relief in otherwise desperate and fatal cases. Recovery may be expected in about two out of five cases, or even in a larger proportion if the operation is *done early.* Speech in some form is retained, and thus a great theoretical objection is removed. But, as in operations for cancer elsewhere, we get our best results here in cases which have not progressed too far.

PARTIAL OR UNILATERAL LARYNGECTOMY.—Inasmuch as laryngeal cancers are more often confined to one side, at least at first, it may be possibly indicated to remove the affected half. Thus, of one hundred and nineteen cases of cancer of the larynx, including the epiglottis,

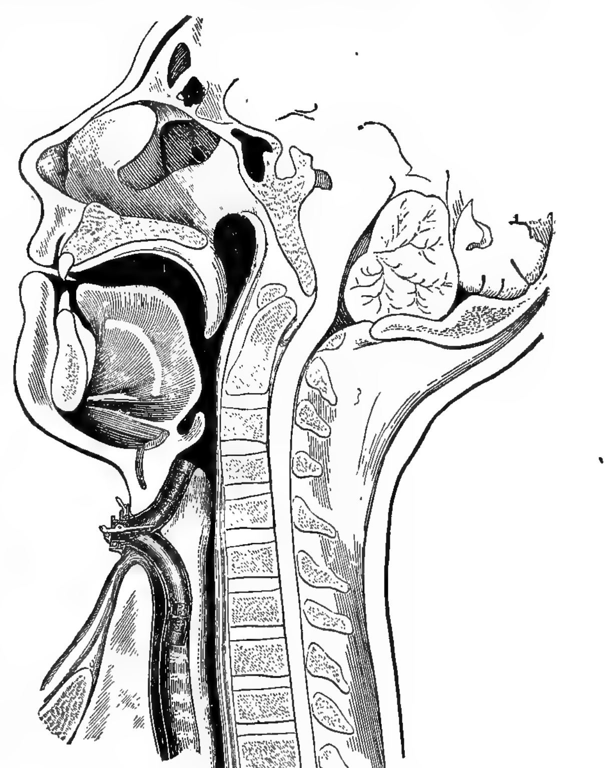

FIG. 3127.—Gussenbauer's Artificial Larynx in Position.

there were sixty-nine in which the disease was unilateral. That partial resection is feasible, some of the earlier cases have abundantly proved. Thus, in Billroth's third case he removed only a lateral half, and still the patient was thereafter able to phonate without mechanical aid. Hahn has advised, as the method of operating in such cases, that by an angular incision the larynx be first exposed, and then split open for examination. If only one-

half be involved, then it alone may be removed; if, however, the disease have advanced beyond the median limit, then the complete operation may still be made. In other words, he recommends an exploratory laryngotomy, to be followed by whatever may be indicated. After the operation a cannula is introduced and packed in the manner above described. If only half the organ have been removed, the patient will probably be able to make himself easily understood without artificial aid.

This partial operation has been successful in about three-fifths of the total number of cases in which it has been practised. Its mechanical difficulties are even greater than those of complete laryngectomy, while there is the added danger of incomplete removal.

Roswell Park.

LARYNX, DISEASES OF: LARYNGOTOMY. See *Tracheotomy.*

LARYNX, DISEASES OF: LEPROSY.—Historical.—In the Ayur-Véda, one of the most ancient of medical writings, suppression of the voice is given among the signs of leprosy,[1] and Hans von Gersdorff[2] states that in the Middle Ages a hoarse voice and shortness of breath were regarded as characteristic of the disease. At the commencement of the present century Martius[3] speaks of ulceration of the palate (velum) and also of the trachea which occasions great difficulty of respiration, as a symptom of the tauric lepra, which occurred in the Crimean war, and which was supposed to have been imported by the Russian troops engaged in the war with Persia. Among other subsequent writers, Struve[4] also alludes to alteration of the voice and difficult breathing; but nothing was known of the laryngoscopic appearances of the affection until their study during life was made possible by the introduction of the laryngeal mirror.

In recent times the disease, as it affects the larynx, has been described by Danielson and Boeck,[5] Hillairet,[6] Wolff,[7] Gibb,[8] Tobold,[9] Schrötter,[9] Virchow,[10] Hebra and Kaposi,[11] Elsberg,[12] Thoma,[13] Eppinger,[14] M. Mackenzie,[15] Macckern,[16] Basini,[17] Thin,[18] Virchow,[19] Plumert,[20] Rake,[21] Kaposi,[22] and others.

Lepra of the larynx is generally secondary to, or appears coincidently with, pronounced lesions of the pharynx or nose, and as a complication of a more or less advanced stage of the cutaneous affection. It may, however, occur without involvement of the skin, as in Elsberg's first case.

The anatomical appearances vary from uniform thickening and redness to extreme tubercular induration and proliferation, which may reach the cartilages and even the structures of the external neck (Virchow). The laryngeal disease develops as a diffuse hyperæmia and swelling of the mucous membrane, or the process may be limited to individual parts, as, for example, the epiglottis. At isolated spots of the hyperæmic laryngeal membrane there develop subsequently hard, nodular, extremely vascular excrescences or tubercles, which are the anatomical analogues of the tubercles on the skin and other mucous membranes. In their incipiency these resemble, according to Virchow, the mucous patches of syphilis. The epithelium covering the tubercles which stud the mucous membrane, as if sprinkled there, is thrown off and granulating ulcers are formed, which finally cicatrize with the production of considerable deformity. Extreme destruction with necrosis of the cartilages is thus sometimes brought about, and the larynx is occasionally so constricted by cicatricial tissue as to threaten danger from suffocation.

The tubercles vary in size from a pinhead or millet seed to a small pea (Wolff). Their number varies considerably; sometimes only a few are found scattered here and there over the membrane, while in other cases they are so closely aggregated as to resemble a diffuse infiltration, which gives to the parts affected a pallid, grayish appearance (Hillairet).

The cicatrices which result from the healing of the laryngeal ulcer of leprosy resemble in physical characters the stratiform scars of syphilis. The tubercular nodules, when examined under the microscope, are seen to be identical in structure with those found on the skin, consisting of a granulation tissue characterized by the presence of the granular lepra cell and bacillus, which shows a remarkable tendency to remain as such, and which ultimately becomes converted into a dense cicatricial mass. In rare instances papillomatous excrescences are observed similar to those which result from syphilitic ulceration.

The leprous process develops slowly in the larynx, and years may elapse before ulceration takes place. The natural tendency is, however, to ulceration and scar formation.

Symptoms.—The symptoms are those of ordinary chronic catarrh. The voice is generally hoarse, and in the subsequent stages of the disease the respiration becomes embarrassed. Secretion is notably increased, sometimes bloody, and, according to Lamblin,[23] the breath is exceedingly fetid, and the thyroid is tender on pressure. In the anæsthetic form of the skin affection the normal sensibility of the larynx is correspondingly diminished.

Complications.—The most dangerous complication, according to those who have resided among the victims of this disease, is acute œdema. In other cases the leprous infiltration leads to disturbances of the motor apparatus of the cords, and, together with the development of fibrous tissue, to stenosis of the larynx and trachea.

Diagnosis.—Although the anatomical diagnosis between this disease and syphilis or lupus may be difficult, from the gross appearances alone, its clinical recognition is always possible from the peculiar appearance of the larynx, the slow development of the affection, and the lesions of the external surface.

Prognosis.—It is sufficient to state that, as laryngeal lepra is the local expression of an incurable general disease, the prognosis is necessarily bad.

Treatment.—The treatment, therefore, is palliative, and must be guided by the general principles involved in the care of chronic laryngitis. Elsberg speaks favorably of the topical use of an ethereal solution of iodoform, and calls attention to gurjun oil (balsam. dipterocarpi) as a valuable local, as well as general, remedial agent. Should œdema occur, the parts must be scarified, and in stricture of the tube, life may be prolonged by tracheotomy.

John Noland Mackenzie.

1 Tom. i. Nidánast'h'ana, id est Pathologia, cap. v., p. 181 (Hessler's translation, Erlangen, 1844).
2 Cited by Virchow: Die krankhaften Geschwülste, ii., S. 519.
3 De lepra taurica, specimen medico-practicum, Lipsiæ, 1806.
4 Ueber die aussatzartige Krankheit Holsteins, 1820. See also extract in the Edinb. Med. and Surg. Journ., vol. xviii., p. 92. See also the work of Ludwig Hunefield: Die Radesyge oder scandinavische Syphiliod, Leipzig, 1828.
5 Traité de la Spedalskhed, p. 121, Paris, 1848; and Atlas, Pl. i., v. and xi.
6 Mém. de la Soc. de Biologie, 1862 (cited by Virchow).
7 Virchow's Archiv, Bd. xxvi., 1863, S. 44.
8 Dis. of the Throat, etc., p. 272, London, 1864.
9 Schrötter's Laryng. Mittheilungen, 1871–73, Bd. ii., S. 84 (cited by Ziemssen).
10 Die krankhaften Geschwülste, Bd. ii., S. 519.
11 Virchow's spec. Path. u. Ther., Bd. iii., Abth. ii., S. 402.
12 New York Med. Record, January 4th and August 2d, 1879.
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15 Dis. of Throat and Nose, London, 1880, vol. i., p. 400.
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18 British Medical Journal, July 19th, 1884.
19 Berlin. klin. Wochenschrift, 1885, No. 12, S. 189.
20 Wiener med. Zeitg., 1884, Nos. 34 to 37.
21 Trans. Path. Soc., London, 1885, vol. xxiii.
22 Wiener med. Wochenschrift, 1885, Nos. 47 to 49.
23 Etude sur la lèpre tuberculeuse, etc., Paris, 1871; Cohen: Dis. of the Throat, etc., p. 531, 1880.

LARYNX, DISEASES OF: LUPUS.—Lupus of the larynx is a form of tuberculosis. It is nearly always consecutive on lupus in other parts of the body, especially in the nose, in the pharynx, or on the skin of the face. Primary lupus involving the larynx and no other portions of the body has been observed by John N. Mac-

kenzie[11] in two cases, by Lefferts[8] in four, by Jonathan Wright in one, and by Rice in three. The epiglottis seems to be the seat of election.

Our positive knowledge of laryngeal lupus dates from the laryngoscopic studies of Türck.[1] The occurrence of the disease in the larynx has also been observed and described by Virchow,[2] Tobold,[3] Ziemssen,[4] Grossman,[5] Thoma,[6] Stilling,[7] Lefferts,[8] Beringier,[9] Eppinger,[10] Morell Mackenzie,[11] Knight,[12] Asch,[12] Breda,[13] Chiari,[14] Bowen,[15] Chiari and Riehl,[16] Hunter Mackenzie,[17] Van Santvoord,[18] and others.

Etiology.—Very little is known as to the etiology of this disease. It has been observed more frequently in those who are the offspring of tuberculous parents or who have brothers and sisters suffering from the ordinary forms of tuberculosis. The slight tendency that this disease has to spread and affect other regions of the body is accounted for in one of two ways: either that the type of tubercle bacillus producing lupus is less virulent than that found in the ordinary forms of tuberculosis, or else that the patient is possessed, by inheritance or otherwise, of a certain power of resistance or partial immunity to the action of the tubercle bacilli, the result being the peculiar pathological changes found in lupus.

Pathology.—The portions of the larynx involved by lupus are usually but slightly reddened and present a nodular appearance with frequently an admixture of cicatricial tissue. The nodules are very slow in formation and consist of numerous, fairly well-organized, round-cell infiltrations with the formation of a few giant cells in this new tissue. The giant cells, when stained by Gram's method, do not always show the presence of tubercle bacilli, a fact which may be accounted for by the sparsity of the micro-organisms. Ulcers may be found over the site of the nodule, and it is not uncommon to find new nodule-formation upon the periphery of the invading inflammatory process, while ulceration is going on just within this border, with complete cicatrization somewhere near the centre of the affected area. The laryngeal surface of the epiglottis is the point where the pathological changes are most frequently observed, although the vocal cords and ventricular bands have been seen to be implicated in the process. The epiglottis is often markedly deformed, and, when the interior of the larynx is involved, considerable stenosis may result from ulceration and cicatrization.

Symptoms.—The symptoms of lupus of the larynx are not very marked. There is ordinarily very little pain, but usually a feeling of constriction in the throat and slight difficulty in swallowing due to the deformed epiglottis. When the interior of the larynx is involved, the changes in the voice and, later, the dyspnœa may cause the patient to seek relief at the hands of the physician.

Prognosis.—This disease is an exceedingly chronic one and especially liable to relapses. It may have existed for months before the patient has been led to seek relief, and even after a quiescence of several years it has been known to break out again. Stenosis of the larynx may occur, demanding relief by tracheotomy to save the patient from asphyxiation. There is also danger that in the process of ulceration some of the bacteria may be carried into the lung, causing pulmonary tuberculosis, or into the circulation, causing the disease to manifest itself in other parts of the body.

Differential Diagnosis.—Lupus may be mistaken for epithelioma, syphilis, or the ordinary forms of tuberculosis. In the article, *Larynx, Diseases of: Tuberculosis*, there will be found a table indicating the differential diagnosis between tuberculosis, syphilis, and lupus, and to this the reader is referred. The differentiation from epithelioma is not so easily made. Lupus is common in early life, while epithelioma rarely occurs before the thirty-fifth year. Epithelioma is accompanied by considerable pain; lupus by little pain. Epithelioma grows rapidly; lupus is of slow development. Removal of a small piece of the growth and microscpoical examination will confirm the diagnosis.

Treatment.—Each case must be treated in the way that experience shows to bring the best results in that case. In some, the use of simple cleansing sprays, such as a solution of sodium bicarbonate, five grains to the ounce, followed by an application of a ten-per-cent. silver-nitrate solution to the ulcerated area, will give good results. In other cases the disease seems to be stimulated to greater pathological activity by this treatment, and in these the use of the sharp curette or the application of the galvano-cautery to the nodules and ulcers is the better treatment. In recent years a number of good reports have been recorded from the use of tuberculin in the treatment of lupus. If this method is adopted it is wise to begin with a dose of 1 to 2 mgm., to be repeated once every four days, unless the reaction is exceedingly marked, in which case the hyperæmia and swelling should be allowed to subside before the injection is repeated. The dose may be increased as the patient becomes tolerant, until one of 10 mgm. is reached. In the case of laryngeal stenosis resulting from cicatrization, tracheotomy is the wiser procedure, as cutting operations and the pressure resulting from intubation tend to aggravate the disease.

The use of the *x*-rays has been suggested for the treatment of this disease, and, when the epiglottis is much involved, it is possible by this procedure to limit its advance; but the treatment has not yet been employed sufficiently to allow us to speak with any degree of positiveness as to its therapeutic value.

Cornelius G. Coakley.

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2 Die krankhaften Geschwülste, ii., Bd. ii., S. 496.
3 Laryngoscopie u. Kehlkopfkrankheiten, S. 307, Berlin, 1874.
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5 Anzeiger d. k. k. Gesell. d. Aerzte in Wien, 1877, 27.
6 Virchow's Archiv, Bd. 55.
7 Zeitschr. f. Chirurgie, 1877, Bd. viii.
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18 New York Med. Journ., December 5, 1885.
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LARYNX, DISEASES OF: NEUROSES.—Neuroses of Sensation.—Under this heading we distinguish three groups: (1) Hyperæsthesia and neuralgia; (2) anæsthesia; (3) paræsthesia.

Hyperæsthesia may occur as the result of external irritation, or as the expression of some internal pathological process, or as an intrinsic alteration of the nerve. The external irritants consist usually of acute inflammatory affections, such as simple acute catarrh, or that resulting from traumatism. When no macroscopic changes are evident, the causative factors are found usually to be hysterical and general nervous affections which are frequently associated with anæmia and chlorosis.

Symptoms.—Under normal conditions, the degree of sensitiveness of the larynx varies greatly in different individuals. Local disturbances from other causes are apt to increase the sensitiveness to a striking degree. Schrötter reports a case of a man with a tumor on the right vocal cord; this was excised, when the patient was suddenly attacked with tonsillitis, which was followed by a great increase of sensitiveness, persisting for several weeks.

The degree of sensitiveness which accompanies acute and chronic laryngitis stands in no direct relation to the macroscopic changes, for in neurotic individuals local alterations of even slight intensity may be accompanied by the most conspicuous hyperæsthesia. The reverse is also the case.

In the majority of instances in which laryngeal hyperæsthesia is dependent upon acute or chronic inflammation of the organ, similar alterations are present also in the

pharynx. We may say, as a rule, that the local alterations consist usually of inflammation, with a tendency to hyperplasia, and that hyperæsthesia in atrophic conditions of the mucous membrane is extremely uncommon. One finds, generally, on examination, a granular condition of the posterior pharyngeal wall, which is due to hyperplastic inflammation of the lymphoid tissue in that vicinity. Gentle contact with the probe is exceedingly apt to excite laryngeal contraction or cough. In such individuals, we find usually either anæmia or neurasthenia, representing one type, or plethora or gout constituting another well-marked class.

In hysteria and hypochondriasis the cause is to be sought in functional disturbances of the central nervous system. In such individuals, the act of swallowing often produces marked discomfort, and patients sometimes complain of a noise which they perceive during the act of swallowing, and which arises from the rubbing of the calcified portions of the larynx on each other.

Neuralgia of the larynx is referred to by various authors as a well-defined affection. It is difficult, however, in many cases to exclude the possible existence of some pathological alteration elsewhere, which may cause the pain. In a case which came under the writer's observation, a severe intermittent, neuralgic pain, extending from the base of the tongue on one side downward in the direction of the cricoid cartilage, was complained of for many years. A true neuralgia was, for a time, considered to exist, but careful inquiry elicited the fact that there had once been a deep-seated abscess in the throat which ruptured externally, the slight scar being completely hidden by a heavy growth of beard. As a rule, such pains do not appear spasmodically, or follow the direction of a definite nerve. Many other causes of laryngeal hyperæsthesia may be enumerated, such as swelling of the veins at the base of the tongue and enlargement of the lingual tonsil. Smoking is also a frequent cause, particularly when strong tobacco is smoked either in a cigar or in a pipe. This condition is found usually in men who are otherwise strong and well, except, perhaps, for certain neurotic tendencies. Such hyperæsthesia is generally associated with symptoms of paræsthesia.

Prognosis.—This depends upon the causative factor. In the catarrhal cases, and in those in which anæmia alone exists, the prospect of relief or recovery is naturally better than in those due to hysteria or hypochondriasis.

Treatment.—This is naturally determined by the etiology. In cases of hyperæsthesia dependent upon or associated with hyperplastic alterations of the mucous membrane, much may be done for the patient by appropriate local treatment. Relief may often be afforded by encouraging the patient to tolerate local applications to the back of the pharynx, which can be carried out at home. The application of Mandl's solution (iodine 0.5 to 1, glycerin 10), on a cotton-tipped probe, may be advantageously practised several times a week. In the case of hysteria and hypochondriasis, general treatment by the family practitioner and neurologist is directly indicated.

Paræsthesia occurs in the form of subjective sensations of constriction, heat, pricking, etc., in the throat, and is usually associated with hyperæsthesia. It is not uncommon as the result of the penetration of foreign bodies into the mucous membrane of the vicinity, and persists often after the foreign body has been removed. In such cases, either as the result of the efforts of the patient to dislodge the foreign body, or in consequence of manipulative efforts of the physician, the mucous membrane of the larynx is often acutely inflamed, particularly in the region of the epiglottis, and this inflammation is almost invariably accompanied by acute lingual tonsillitis. In such cases, it is difficult to determine which region of the throat is responsible for the persisting symptoms of discomfort.

The treatment of such conditions follows closely the lines laid down for hyperæsthesia. In addition to such general measures as will suggest themselves to every physician in the way of diet, hygiene, and appropriate tonics, much relief may be obtained from local treatment. A frequent application of Mandl's solution in cases characterized by hyperplasia of the lymphoid tissue is serviceable. When the pain is very severe, Gottstein recommends the application to the neck of cloths wrung out of very hot water. The prognosis in cases not due to the entrance of a foreign body is undoubtedly less favorable than in hyperæsthesia.

Anæsthesia.—Diminution of sensibility in the larynx may be partial or total. In the first instance, the condition is called hypæsthesia, in the second, anæsthesia proper. These conditions are to be distinguished from loss of the sense of pain, or analgesia. In the diagnosis of anæsthesia, it is often difficult to determine the boundary between normal degrees of tolerance and pathological conditions. In certain individuals it is possible to introduce laryngeal instruments without previous anæsthetizing of the parts, and yet no evidence exists pointing to any abnormality, either general or local. A frequent cause of anæsthesia is to be found in diphtheria, and this may at times be associated with anæsthesia of the soft palate and uvula. There seems to be no relation between the severity of the infection and the degree of paralysis present. The time of onset of such nervous alterations in the larynx ranges from two to six weeks after recovery from the diphtheria, but it may extend to from two to four months. Paralysis in this affection is probably due to alterations produced in the nerves by the diphtheria toxin. Syphilis of the central nervous system may produce anæsthesia in the larynx. Ott observed anæsthesia of the right half of the larynx in a case of paralysis of the right vocal cord, due to syphilis of the central nervous system. The roots of the vagus showed no medullary nerve fibres. Schrötter has reported a case of malignant lymphoma of the throat in which individual tumors extended up the left side of the neck between the mastoid process and the ramus of the lower jaw. In addition to paralysis of the left vocal cord, there was also anæsthesia of the left half of the larynx. In this case the root of the vagus must have been subjected to pressure before giving off its individual branches, since, in addition to paralysis of the left laryngeal muscle, there existed also an acceleration and irregularity of the heart's action.

Both anæsthesia and hypæsthesia occur in hysteria, although they are rare manifestations in this disease. The anæsthesia may be total or unilateral, and may be associated in the latter instance with unilateral cutaneous anæsthesia. Unilateral anæsthesia has been reported in cases of hemiplegia, although this is less common than cutaneous anæsthesia; it has been noted also in association with unilateral lesions of the medulla, bulbar paralysis, tumors of the base of the skull, gummata, progressive muscular atrophy, railway spine, and tabes. Krause reports a case of tabes in which there was anæsthesia of the laryngeal mucous membrane with, however, well-preserved reflex excitability, as shown by probing, which caused closure of the glottis. In another patient, the reflex irritability disappeared, while sensation was preserved.

When the anæsthesia is complete, there is a marked tendency for food and drink to enter the trachea, with the production of glottic spasm or cough. It has been stated that the epiglottis in this condition is more erect than usual, owing to paresis of the thyro- and aryepiglottic muscles, which are said to be supplied with motor filaments by the superior laryngeal nerve.

The prognosis of laryngeal anæsthesia is dependent upon the etiology in each case. In diphtheria the condition usually passes off spontaneously. In the functional nervous diseases the prognosis may or may not be good, according to the underlying general disease.

In organic diseases of the nervous system the same is true, so that it is useless to formulate any definite statements. Treatment consists in that which is appropriate to the general underlying cause. It is important to prevent food from entering the larynx, and it may be necessary to feed the patient through a tube.

Spasmodic Affections.—*Spasm of the Glottis.*—Glottic spasm may affect the abductors as well as the adductors. But a single case, however, of the former condition is known, namely, one reported by Pitt as occurring in a patient with hydrophobia, in whom the glottis remained wide open for several seconds during the attack. Almost universally the term spasm of the glottis is employed to designate spasm of the adductors. It occurs most commonly in children, and is then usually dependent upon or related to rachitis. As contributing causes we may mention general disturbances of nutrition, improper feeding, and acute local inflammations. In adults there is usually an associated chronic laryngitis, although new growths have been observed to produce such attacks. Lichtwitz has described hysterogenic zones in the larynx, contact with which excites glottic spasm. The laryngeal surface of the epiglottis seems to be especially sensitive. Spasm of the glottis is common in tabes, and may be an initial symptom. It may also occur in association with chronic catarrhal inflammation of the parts, particularly in alcoholics. Lesions of the naso-pharynx, particularly those of a hyperplastic nature, often give rise to a spasmodic contraction of the nerves. Tetanus has been occasionally found to exhibit this condition. The symptoms vary according to the degree and duration of the attack, as well as to the underlying cause. The attack is ushered in usually by cough, with simultaneous sensation of contraction in the throat, followed by cyanosis and even unconsciousness. In a few seconds, a spasm may be interrupted by deep inspiration, which is followed by another contraction. The patient experiences marked anxiety and a sense of impending dissolution, and sometimes a fatal termination may actually ensue. Examination of the larynx shows a close approximation of the vocal cords throughout their whole length, although at times their cartilaginous portions may remain open, producing a triangular cleft posteriorly. The ventricular bands may also share in the contraction. The epiglottis may be depressed, but usually stands erect.

The diagnosis is readily made from a consideration of the symptoms, although the condition must be differentiated from that following secondary contractions which take place in paralysis of the postici.

Prognosis is usually favorable, but is dependent upon the underlying cause and the treatment. In children, the condition is more serious, and a considerable number of fatal cases have been reported.

Treatment.—The first indication during an attack is to produce relaxation of the contracted muscles, which may be effected by the inhalation of chloroform, ether, bromide of ethyl, sudden application of hot water to the neck and back, or of cold water to the epigastrium. Tracheotomy has been found necessary at times. For the prevention of the attack, appropriate general measures must be instituted. In children this is particularly important. Heroin in small doses has been found particularly serviceable. Schrötter recommends the introduction, in hysterical cases, of a hard-rubber tube.

Chorea of the the Larynx.—True laryngeal chorea is characterized by a choreic movement of the vocal cords, in association with a true general *chorea minor.* The designation "chorea of the larynx" is superfluous, since the laryngeal muscles move in sympathy with the general muscular system. Onodi therefore proposes to drop the name "chorea laryngis" and recommends, in cases of choreic movement of the cords, without general chorea, that the term "choreiform movement of the cords" be used. Cases of nervous cough upon which chorea supervenes are to be termed "chorea minor, with nervous cough." The name "chorea laryngis" is therefore inapplicable to many cases of nervous, reflex cough, which have been described by various authors under that designation.

Nervous Cough.—By this term is denoted a cough which arises without demonstrable alterations in the mucous membrane, and is occasioned by reflex irritation from without, or by an increased irritability of the central nervous system. Although no macroscopic alterations may be found on examination, it is possible that the condition is due to some previous disease, such as acute inflammation or new growths. Among other external sources of irritation, we may enumerate diseases of the nose and pharynx, particularly chronic follicular pharyngitis. The condition under these circumstances is closely allied to that which exists in hyperæsthesia of the larynx. Reflex irritation due to the presence of wax or foreign bodies in the external auditory meatus is somewhat frequent.

Among the factors associated with increased excitability of the central nervous apparatus, we find, first, anæmic conditions, secondly, hysteria. A form of cough which occurs in tabes may also be included here.

Symptoms.—The attack of coughing is usually preceded by sensations of tightness or constriction in the throat, which cause a desire to clear the parts. The cough may occur only once or be repeated, and there may even be spastic contractions of the abductors, associated at times with energetic contraction of the diaphragm. The character of the cough varies, but it is usually dry and tight, although at times there is a rough or bellowing quality. There is little or no expectoration. The prognosis and treatment depend upon the underlying causes.

Motor Paralyses.—These may be divided into three general classes as follows: 1. Paralysis of the closers of the glottis, namely, the lateral crico-arytenoid muscles (or adductors proper), the thyro-arytenoid (or internal tensors of the vocal cords, which also aid in closing the glottis), and the interarytenoid muscle. 2. Paralyses of the abductors or posterior crico-arytenoid muscles. 3. Paralyses of all the muscles supplied by the recurrent laryngeal nerve. Paralyses of the laryngeal muscles are occasioned either by disturbances of the nerves which supply the organs, namely, the recurrent laryngeal and the superior laryngeal, or by lesions of the vagus and the accessorius, from which these nerves arise. These we term peripheral disturbances. Paralysis may also arise in consequence of intracranial diseases affecting the nuclei of the roots of the vagus and the accessorius, giving rise to central paralysis. Finally, we distinguish myopathic paralyses, produced by diseases of the muscles themselves. These paralyses are scarcely separable from the peripheral, inasmuch as their etiology and manifestations are as yet imperfectly understood. In view of the long course of the vagus and its exposed situation, it may experience a variety of injuries through lesions of the structures in the vicinity. Among these we may enumerate traumatism, pressure from mediastinal tumors, enlarged bronchial glands, aneurism of the innominate and subclavian arteries on the right side and of the arch of the aorta on the left, carcinoma of the œsophagus, and enlargement of the thyroid. Diseases of the pleura and of the right apex may produce paralyses of the recurrent nerve. Paralyses of the vocal cords have also been observed in consequence of the pressure of malignant tumors on the accessorius, within the cranial cavity. Remak has described traumatic paralyses of the sympathetic, hypoglossus, and accessorius. In diphtheria paralysis of the superior laryngeal nerve has been found, though it is extremely rare.

Among the peripheral paralyses we include those of myopathic and neuropathic nature, which affect usually only individual muscles, and arise in consequence of overexertion. These are most frequently due to catarrhal diseases. Certain infectious diseases are followed at times by more or less complete paralyses on the part of the laryngeal muscles. We find this particularly in diphtheria, typhoid fever, smallpox, scarlet fever, and erysipelas. These are due probably to the action of the toxins upon the nerves in question. Those paralyses which occur in consequence of tuberculosis and syphilis are, on the other hand, usually due to alterations of the tissue in the vicinity, rather than to a toxic action. Lead and arsenic poisoning have been observed to occasion laryngeal paralyses. Rheumatism has been cited frequently as a cause of laryngeal paralysis. Bäumler de-

scribes an independent affection of the recurrent nerve in the form of a chronic neuritis, and attributes it to inflammatory processes in the neighborhood of the nerve—particularly enlarged bronchial glands,—which arise, not uncommonly, in consequence of long-continued inhalation of dust. Complications of laryngeal paralyses with those of other cerebral nerves have been observed. Paralysis of the velum is frequently associated with, and has been observed to follow, influenza.

Pathological Anatomy.—The histological alterations in the larynx depend upon the etiology and the duration of the affection. The nerves may exhibit different degrees of atrophy, varying from simply fatty or amyloid degeneration to a complete disappearance of the nerve substance. Ziemssen has found post mortem, in cases of peripheral paralyses of individual muscles, a degeneration of certain nerve bundles. The alterations in the muscles depend upon the duration of the disease. In cases of long standing, they appear of a pale yellowish-brown color. The muscle fibres show interstitial proliferation of the nuclei, together with atrophy and fatty degeneration.

Having thus reviewed the laryngeal paralyses from a general standpoint, we pass to a more detailed consideration of the individual groups.

Paralyses of the Tensors of the Vocal Cords.—We have to do here with paralyses of the crico-thyroid and the internal thyro-arytenoid. The crico-thyroid muscle is supplied chiefly by the superior laryngeal nerve, with also a few fibres from the inferior laryngeal nerve. Although the crico-thyroid muscle possesses the function of rendering tense the vocal cords, it is aided by the simultaneous action of the internal thyro-arytenoid. When the former muscle alone contracts, the larynx is unable to produce the highest tones possible, and the margin of the vocal cords does not exhibit a straight line, but rather an outward bowing. In a case reported by Tuerck, of paralysis of the left thyro-arytenoid muscle, the ligamentous glottis had the shape of a strung bow with the convexity toward the left.

Cases of paralysis of the crico-thyroid muscles alone are not common, although Schrötter believes that many patients who have lost their singing voice, without exhibiting abnormalities in the configuration and color of the larynx, suffer from paresis of these tensors. In unilateral paralysis, the healthy cord has been found on a higher level than the paralyzed one. Moser observed a case in which the posterior portion of the paralyzed cord stood higher than the anterior portion. Kiesel and R. Wagner found an eversion of the arytenoid while at rest. Gottstein and Jurasz believe that all cases of phonation in which there is a normal closure of the glottis without the vibration of the vocal cords, depend upon paralysis of the crico-thyroid.

Paralysis of the Adductors.—The adductors of the cords are the lateral crico-arytenoid muscles, the transverse arytenoid and the external thyro-arytenoid, all supplied by branches of the recurrent. There may be a complete paralysis of all the adductors, or a paralysis of one or more in various combinations.

Paralysis of all the Adductors is found most frequently in hysteria, and is marked by complete aphonia, which may come and go irregularly. This complete paralysis may alternate with one or more of the partial paralyses shortly to be described. Examination of the larynx shows usually a bilateral paralysis, although one cord may exhibit a tendency to slight movement on phonation. Gottstein has called attention to the fact that the immobility of the cords exists only upon attempted phonation, since they may be induced to move by contact with the probe, this showing that the reflex irritability is preserved.

Paralysis of the Lateral Crico-arytenoid.—Isolated paralysis of this muscle is rare, since the transverse arytenoid and the thyro-arytenoids are usually affected to a greater or less degree. Laryngoscopic examination shows the opening of the glottis during phonation in the region of the points of the vocal process.

Paralysis of the Transverse Arytenoid.—This is a common form, found usually in consequence of acute inflammation, although also seen in cases of hysteria. Examination of the larynx shows a triangular cleft in the glottis, corresponding to the cartilaginous portions of the vocal cords, while the ligamentous portion of the glottis is closed.

The prognosis of these conditions is favorable, although in hysterical individuals, constant relapse is apt to occur.

In the treatment one must have in mind the general as well as the local condition. With regard to the latter, the application of electricity has been of service. The interrupted current is used. One pole attached to a metal plate is fixed over the thyroid, the other connected with a laryngeal electrode is introduced as far as the arytenoid region, and then a strong current is suddenly passed through.

Paralysis of the Abductors.—The posterior crico-arytenoid muscles have the function of opening the glottis in respiration. Unilateral paralysis is by no means rare. Among the causes of this condition we may enumerate tabes, bulbar paralysis, multiple sclerosis, injuries to the brain and cerebral tumors, injuries of the neck affecting the pneumogastric nerve, pressure from tumors or aneurism in the neck and thorax, and finally malaria and poisoning with lead, arsenic, or belladonna. Owing to the longer course of the left recurrent nerve, and its greater liability to involvement by tumors, left abductor paralysis is the more frequent. Inflammation of the pleura at the right apex has been found to affect the right recurrent nerve. Unilateral paralysis can of itself never progress to bilateral paralysis, inasmuch as there are no centripetal fibres in the recurrent. Laryngoscopic examination shows that the healthy cord on phonation often passes over the middle line, so that a weak, husky voice is often possible. Inspection reveals the paralyzed cord to be in the cadaveric position, with a concave inner margin. During phonation the healthy cord passes over the other arytenoid, and produces an oblique position of the glottis. At times the arytenoid of the paralyzed side makes a twitching movement during phonation, and may even pass over toward the healthy side. This phenomenon is probably due to the passing over of nerve fibres into the transversus from the healthy side.

Bilateral paralysis of the abductors may be produced by any of the causes enumerated above. As has been previously shown, the abductor fibres are the first to suffer from any lesion affecting the motor filaments of the larynx between the spinal accessory nucleus and their terminations. We may thus find abductor paralysis as a premonitory symptom of complete recurrent paralysis. Bilateral paralysis has been observed particularly in tabes and syphilis. If it is an early stage of recurrent paralysis, the severe dyspnœa which it produces is relieved as soon as both cords assume the cadaveric position. The symptoms are chiefly those of severe inspiratory dyspnœa, particularly during sleep. Examination shows the vocal cords lying more or less parallel with each other, separating slightly on expiration.

Treatment.—When the cause of the condition is unknown it is well to treat the case as one of a syphilitic nature, by the administration of iodide of potassium. For the relief of the dyspnœa tracheotomy or intubation may be necessary. Excision of the vocal cords has been done, but with unsatisfactory results.

Complete Bilateral Paralysis.—This extremely rare condition has been observed in compression of both recurrent nerves by cancer of the œsophagus, aneurism of the aorta, or tumors of the thyroid. Johnson, Bäumler, and others have noted bilateral recurrent paralysis as a result of pressure on the vagus of one side. This is explained by Johnson on the hypothesis of reflex paralysis; the compressed sensory fibres of the vagus transmit the irritation to the nucleus of the accessorii with the result of producing paralysis of the muscles on the opposite side. Gottstein thinks it more probable, however, that the irritations of longer duration which affect one vagus, result finally in central lesions and produce changes in both accessorii.

Joseph Lincoln Goodale.

LARYNX, DISEASES OF: NEW GROWTHS.—Classification and History.—Laryngeal neoplasms, like tumors in any other portion of the body, are clinically divisible into benign and malignant growths, and this division, although based upon purely clinical knowledge, may with propriety be retained, as may also the purely anatomical division of laryngeal neoplasms into extrinsic and intrinsic (Grieshaber), namely, those which start from without the true anatomical confines of the laryngeal cavity and those which start from within that organ. There is also another clinical division into primary and secondary or metastatic laryngeal tumors. One of the above classifications will serve a better purpose in a treatise on tumors of the larynx than would a strictly histopathological division of these growths, although the latter cannot be wholly ignored.

Prelaryngoscopic records furnish but few instances in which intralaryngeal neoplasms were discovered and successfully removed during the life of the patients, but there are a few cases in which a tumor located high up in the larynx, or attached by a long pedicle so that it could be brought into view when the tongue was depressed, was diagnosed and removed. Most of these tumors were, however, first discovered post mortem, the clinical signs to which they had given rise during the lifetime of the patient having remained unappreciated. Middeldorpf in 1854 collected the histories of all the cases then on record, sixty-four in number, in nine only of which had any attempt been made to remove the neoplasm. To Kaderik in 1750 is due the credit of having removed a laryngeal tumor *per vias naturales*. Seventeen years later, Lieutard reported two undoubted cases of the same nature. Brauers in 1833 attempted to remove a laryngeal neoplasm by thyrotomy, and Regnoli in 1836 succeeded after a preliminary tracheotomy in extirpating a growth through the mouth. A little later we find a description of laryngeal tumors in Ryland's classical work, and after a long interval Ehrmann's celebrated treatise appeared (1850), containing a description of thirty-one cases. To these, in 1851, Rokitansky added ten cases. Green followed in 1852 with thirty-nine cases, Gurdon Buck in 1853 with forty-nine, and finally Middeldorpf in 1854 with sixty-four, bringing the history of these neoplasms down to the date of the introduction of the laryngoscope into medical practice in 1858.

From this date the subject enters into an entirely new phase; its historical interest ceases, while its practical importance begins to develop. The rapid progress in special knowledge, resulting in an immense increase in the number of laryngeal tumors diagnosed, and the impetus given to intralaryngeal surgery by the success of von Bruns in removing a laryngeal fibroma by the natural passages with the aid of the laryngoscope (1861), have all been the natural outcome of the discovery of this instrument. Among the advantages derived from the intelligent use of the laryngoscope are the detection of approaching stenosis, the determination of the time when tracheotomy is necessary, and the ability to watch the result of medical and surgical treatment.

Malignant growths of the larynx, as primary affections, are extremely rare in the prelaryngoscopic history of laryngeal affections. The laryngoscope, however, has not only aided in the early recognition of these growths, but has also put it in the power of the physician to observe their gradual development. In 1837 an instructive case of primary cancer of the larynx was reported by Trousseau. Louis and Barth each recorded a case, the latter in 1854. A number of cases of so-called carcinoma extending from the œsophagus, tongue, tonsils, or pharynx to the larynx were reported at an early date, but Fauvel regards these as "cancers of vicinity" and not, properly speaking, secondary or consecutive tumors of the larynx itself. In the past ten years numbers of cases of primary laryngeal carcinoma have been reported; in most instances the diagnosis being confirmed by histological examination. The case of General Grant and that of Emperor Frederick of Germany both served to direct universal attention to cancer of the throat and to demonstrate the inestimable value of the microscope and laryngoscope as diagnostic aids, and also the utility of cocaine in diagnosis and treatment.

Etiology.—Before the introduction of the laryngoscope, it is natural that the number of intralaryngeal neoplasms was supposed to be extremely small, inasmuch as they could be diagnosed only post mortem; and besides, owing to the difficulty of making an examination of the parts, and to the disfigurement of the body necessitated by the removal of the larynx from the subject, many cases escaped observation. Since Czermak, however, demonstrated the possibility of inspecting the larynx upon the living subject, neoplasms have been frequently discovered in this organ, and their growth and development, together with the etiological factors, have become absorbing subjects of study for laryngologists.

From a review of the literature of this subject we are forced to the conclusion that chronic catarrhal inflammation of the laryngeal mucous membrane and of that of the neighboring cavities of the upper air passages stands in the first place among the etiological factors; it must be borne in mind, however, that this condition is not the only cause, for chronic laryngeal catarrh may often exist for some time without giving rise to neoplasms. The occurrence of tumors in the larynx has been referred to a variety of ultimate causes, such as occupation, climate, and irritation of the vocal cords by overstraining, as in speaking, singing, etc., and particularly by the persistent use of the voice in singing during the period of mutation, at the age of puberty in the male (Fauvel); but all these conditions are merely causes producing chronic inflammation and not direct causes of the growth of the tumors themselves. The same may be said of the exanthemata as direct causes of laryngeal neoplasms (Lefferts).

What might be termed chronic traumatism (Seiler)—that is to say, repeated irritation of the laryngeal mucous membrane by the abuse of the voice in singers and speakers, by the inhalation of acrid vapors, dust, etc.—is, like the factors above mentioned, of indirect etiological significance only; and all cases in which traumatism has been alleged as a cause, such as fracture of the larynx by attempted choking, gunshot wounds, inhalation of caustics, etc., must be excluded for want of conclusive evidence that the acute traumatism was the exciting cause of the neoplasm. A case cited by Fauvel, in which there was an external wound in the neck, is the only one that I know of in which we can with certainty refer the occurrence of the neoplasm to trauma. The French school of laryngologists mention a rather curious etiological factor, namely, the "polypoid diathesis," which evinces itself particularly in the young, by papillomatous growths in various parts of the body, and which Dr. Charles Nancrede, of Ann Arbor, some years ago explained on physiological principles in a paper read before the Philadelphia Pathological Society. Heredity has also been assigned as an important etiological factor, especially in cases of malignant growths, but confirmatory data on this point are wanting. There is, furthermore, no clear evidence that laryngeal neoplasms are ever congenital.

We may assume, however, with propriety, that in certain persons a condition of the system exists which predisposes them to localized cell proliferation and therefore to the formation of neoplasms. These will naturally form in such portions of the body and such tissues as are subjected to local irritation, and in this connection it is well to remember that some individuals are more prone to the development of local accumulations of embryonal cells (carcinoma and sarcoma), while others, probably of a more vigorous constitution, are more prone to the development of local hyperplasiæ of fully formed tissue cells (fibroma, lipoma, papilloma, etc.).

It is in the instance of papillomata that we find a line of demarcation distinctly drawn between the benign and the malignant tumors, for, as Nancrede has pointed out, a given subject with a predisposition to the development of papillomata will develop such growths only in early life; but this dyscrasia, if it exerts its influence in later life, when the superficial epithelial layer of the skin and

mucous membrane have become hardened and indurated, while, at the same time, the connective-tissue layer of the subdermal and submucous tissues has become weakened, will result in a malignant epitheliomatous growth, the cell proliferation following the line of least resistance and invading tissues where epithelial cells do not properly belong.*

Chronic systemic intoxication, like alcoholism, syphilis, tuberculosis, and even the excessive use of narcotics, has been mentioned as a cause; but it must, from the standpoint of both the clinician and the pathologist, be looked upon only as a predisposing cause and not as a direct one.

Syphilis, as well as tuberculosis, by giving rise to temporary local hyperplasias or tumors (gummata and condylomata) may mislead the observer in his diagnosis. Although, strictly speaking, these are tumors or neoplasms, yet, owing to their very nature, they are self-evidently only pseudo-neoplasms.

One important etiological factor in the production of carcinomata or malignant growths of the larynx is said by some writers to be the local irritation resulting from repeated attempts at removal of a benign tumor through the natural passages. A striking illustration of this, according especially to certain German laryngologists, is to be found in the case of Emperor Frederick III., who was operated upon nine days in succession with the galvano-cautery by one of the German military surgeons for a papilloma, the nature of which as a benign tumor had previously been demonstrated by no less an authority than Professor Virchow. Still the majority of close observers are agreed in declaring that a benign growth will not of itself change into a malignant one, and cannot be made to do so, and this opinion is borne out by the pathologist.

Finally, invasion of the laryngeal cavity proper by extrinsic neoplasms and the deposit of metastatic foci of cancerous growths must be mentioned as a factor in the production of intralaryngeal neoplasms.

Of late, much has been written about the parasitic nature of cancer; but this has been by bacteriologists and not by pathologists. I mention this only to register my belief that the theory is utterly without foundation.

Frequency.—The relative frequency of laryngeal neoplasms, among all the diseases of the upper air passages, is extremely difficult to establish with any degree of accuracy, because, as already stated, before the introduction of the laryngoscope, no data were obtainable, except post mortem, and consequently the statistics were misleading. On the other hand, in the early days of laryngology, before the different laryngeal diseases were thoroughly understood, when expert laryngologists were few and far between, a neoplasm was naturally the most easily detected lesion in the living subject, and consequently the number of cases reported rose to a very high percentage. The advances made in the diagnosis and treatment of chronic laryngitis (one of the chief causes, as we have seen, of laryngeal neoplasms), since the discovery of the laryngoscope, and the more general instruction in its use given in the medical schools, have as a direct consequence reduced the relative frequency of new growths of the larynx.

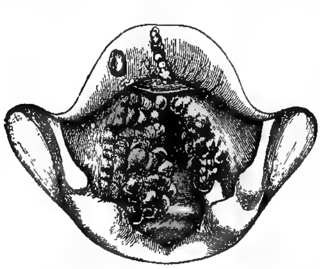

Fig. 3128.—Papillomata on the Vocal Cords.

As experience has proved, Lefferts was perfectly correct in his statement, in the first edition of this Handbook, that laryngeal neoplasms, both of the benign and of the malignant type, are much more frequent in the male than in the female, and that also, with the exception of singers and public speakers, vocation, heredity, and climatic influences are of very little consequence numerically speaking.

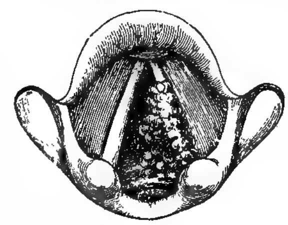

Fig. 3129.—Papillomata on the Right Ventricle of Morgagni.

The one exception—that, namely, of public speakers and singers, who suffer most frequently from laryngeal neoplasms—does not prove that the proper use of the voice predisposes to new growths, but rather that the cause lies in the frequent *abuse* of the voice (Labus, E. Seiler).

As uncertain as statistics have proved to be in regard to the frequency of tumors in the larynx in the general run of cases, both in public and in private practice, so also have statistics collected by me for a period of over thirty years proved unsatisfactory in establishing any trustworthy data in regard to the frequency of occurrence in the different nationalities and races.

Clinical and Pathological Aspect of Laryngeal Neoplasms.—From the foregoing the reader will very readily gather that at the present time and in the present state of laryngological and histopathological knowledge the diagnosis of the nature of a neoplasm, no matter where situated, must go hand-in-hand with that of its presence. I have thought best, therefore, in this brief article, to combine the clinical aspect, the location, and the histological distinction between the different growths under one head, and I will begin my description with the neoplasm most frequently met with, namely, papilloma.

Papilloma.—Papillomata, in order of frequency, assume the first rank, not only in adults, but especially in children. They vary greatly in size, viz., from a millet seed to a walnut. Their most common situation is on the anterior two-thirds of the vocal cords; on the ventricular bands they occur more rarely; and they are hardly ever seen in the posterior commissure or in the posterior portions of the larynx. On the epiglottis they are seldom observed.

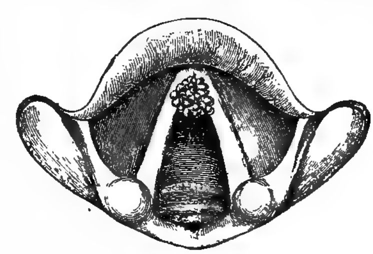

Fig. 3130.—Papilloma at the Angle of the Glottis.

Clinically, three varieties of these tumors are met with: The first class includes small light-red tumors of uneven surface and broad base, generally scattered and never of great size. After removal their recurrence is unusual. The second variety is a whitish-gray (the white growths are frequently mistaken for condylomata), papillary, warty tumor, seated upon a broad base and springing usually from the vocal cords. It recurs very slowly after removal, if at all. The third form, the most intractable as regards recurrence, is the large reddish tumor, single or multiple, variously designated by different authors as cauliflower, raspberry, strawberry, mulberry, etc. They grow rapidly and invade all parts of the laryngeal cavity. These papillary growths, when they have assumed considerable size, become dangerous, not because of any tendency to carcinomatous degeneration, but on account of their bulk, by which they obstruct normal respiration, causing dyspnœa or even apnœa. They are frequently ulcerated in consequence of necrosis of the superficial cells resulting from the insufficient blood supply. The latter fact is in all probability due to the constriction of the supplying blood-vessels in the usually slender stem of these growths, this constriction being caused by the

* Perhaps the best definition of what constitutes a cancer, in the mind of the pathologist, is the same as the definition given by Balzac in his "Country Doctor" of dirt—"the right thing in the wrong place."

pressure exerted by the growths themselves upon the surrounding tissue.

Fibromata.—These growths are second in order of frequency. They are usually red in color. They are as a rule sessile when located, as they usually are, on the vocal cords, but may be occasionally met with as pedunculated growths. They may be regarded as intrinsic neoplasms when they are attached to the cartilaginous structures of the larynx, namely, the perichondrium of the epiglottis, the arytenoid cartilages, or the cricoid; or as extrinsic when they spring from the lingual face of the epiglottis, the aryepiglottic folds, the hyoid bone, the larger cornua of the thyroid cartilage, or the articulation of the thyroid ligament. Their surface is smooth, they always occur singly in the larynx, and they are of slow growth. After removal they have no tendency to recur.

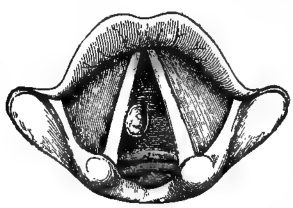

FIG. 3131.—Fibroma on the Left Vocal Cord.

Histologically, the hard fibroid tumor is made up of interlacing bundles of white fibrous tissue generally covered by several layers of epithelial cells. The softer forms of fibroma (sometimes called cellular fibroma) are largely made up of more or less developed fibro-cellular tissue, diffused through the meshes of which is a quantity of serum-like fluid.

The vascular supply of both varieties is but slight, and is always accomplished by anastomosis from the adjacent tissues on which these tumors are located, except in the rarer pedunculated variety, in which, as in the fibrous polypi of the nasal cavity, we not unfrequently find a large artery in the centre of the pedicle which carries the blood supply to the neoplasm.

Cystic Growths in the larynx rarely attain a large size. On the lingual face of the epiglottis, their favorite seat, they are usually seen of the size of a pea, although there are a few cases on record in which they have attained a larger size than that of an ordinary split pea. Their color is yellow or white. They have dense walls, and are filled with a thick gelatinous material. When situated on the vocal cords, they are always seen on the free edge, and their wall or enveloping membrane is much thinner than when they are situated elsewhere within the laryngeal cavity, because the epithelial covering of the vocal cords themselves is of a more delicate structure and of a different variety (squamous) from that of the epithelial covering of the rest of the surrounding mucous membrane. Rupture of these cysts is not unusual when they are seated in this locality. Cystic growths, when laid open and their contents emptied, show no tendency to recur.

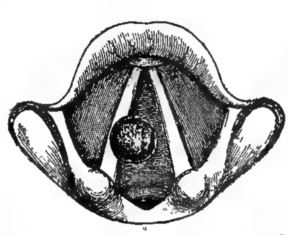

FIG. 3132.—Fibroma on the Left Vocal Cord; Growth of Larger Size.

Histologically, they belong to the class of retention cysts, and therefore it is natural that they should be most frequently located in those portions of the laryngeal cavity which abound in racemose glands, as the epiglottis, the aryepiglottic folds, the ventricular bands, and the ventricle of Morgagni.

A few cases of inversion of the ventricle have been reported (Cohen, Fauvel), and these—as the writer has personally verified in an unreported case—closely resemble a cystic laryngeal neoplasm.

Lipoma.—Among the rarer forms of laryngeal neoplasms—which indeed are rarely seen even by the specialist—are such tumors as the lipomata, which are to all intents and purposes nothing but encysted overgrown fat cells.

Myxomata, which, strange as it may seem, are so frequently found within the nasal cavity in the shape of soft polypi, are rarely seen in the larynx. They constitute the so-called polypi of the older writers. They are composed of a bag covered with a thin layer of epithelium and filled internally with delicate interlacing fibrous strands, the large meshes of which contain a gelatinous mucoid substance. In the larynx they rarely attain any great size. Their most frequent seat is the lower or laryngeal face of the epiglottis, when by their mechanical interference with the complete closure of the glottis they have, in the few cases reported, caused partial or complete aphonia.

Adenomata and *Angiomata*, owing to the physiological function of the upper air passages, as well as to the anatomical structure of the larynx, are extremely rare, as are also *fibromyxomata*, of which there is but one positive case on record, the writer's, and but one case of intercanicular fibroma, of doubtful diagnosis, reported by E. O. Shakespeare, and supposed at first to have been a case of angioma.

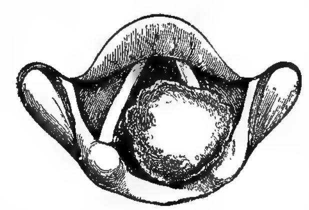

FIG. 3133.—Lipomatous Growth.

Malignant Tumors.—Among the so-called malignant neoplasms which we encounter clinically in the laryngeal cavity, first in point of frequency should be mentioned *epithelioma*.

But I wish most emphatically to express my opinion—which is that of many others—that epithelioma is not a true malignant neoplasm, any more than is a miliary tubercle, a condyloma, a gumma, or a rodent ulcer. The only difference between a benign and a malignant growth consists in the histological elements. In the one case (the benign) these are of the mature, perfect type, and therefore metastasis, histologically as well as clinically, is impossible. On the other hand, the cell elements of the second (the malignant) are embryonic in their type and may under favorable circumstances develop into farther advanced stages of embryonic cell structure, but under no circumstances can they attain to the mature type (Rindfleisch, Rokitansky, Virchow, S. Gross, Jr., Green, etc.). It is to my mind preposterous, from a purely histological and pathological point of view, to assume that a benign tumor, made up of mature histological elements, can be made to degenerate by local irritation into a malignant growth, composed of embryonic cell structure. It would be as sensible to assert the possibility of reducing, by local irritation, a hen into her original embryonic ovum.

Of course it is hardly necessary to recall to the mind of the reader that malignant neoplasms are subdivided into carcinomata and sarcomata, the first of which are made up of embryonic epithelial cells, the second of embryonic connective-tissue cells; nor is it necessary to dilate upon the fact that retrograde metamorphoses into various forms more readily obtain in such embryonic adventitious tissue. A translation from a focus in one organ to another distant one, by metastasis, is a fact of common clinical observation, and, as the lymphatics are the carriers and disseminators of these embryonic seed cells, we find that the lymphatic glands in the neighborhood of the original focus of the malignant growths are usually the temporary arresters of the progress of metastasis, and from overwork and constant irritation they become inflamed and enlarged, this enlargement forming one of

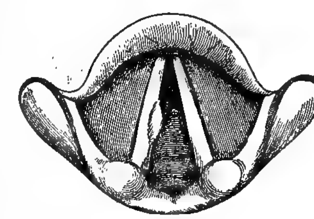

FIG. 3134.—Colloid Tumor on the Left Vocal Cord.

the most certain clinical features in the diagnosis of cancer.

Epithelioma is the most frequently observed of these malignant growths in the larynx and is usually seen on the mucous membrane of those portions of the upper half of the laryngeal cavity which are most prone to local irritation, namely, the upper surface of the vocal cords, the upper edge of the epiglottis, the laryngeal surface of the epiglottis, the ventricular bands, and the anterior commissure; in fact, the very same localities in which, as has been mentioned, papillomata most frequently occur.

Sarcoma, the form of cancer made up of embryonic connective-tissue cells, is extremely rare as a primary growth in the larynx, as also is the medullary form; but in the few cases of the latter, which undoubtedly can be looked upon as primary, the growths have sprung from the vocal cords, the laryngeal face of the epiglottis, the aryepiglottic folds, the ventricular bands, and the anterior commissure, while the few primary cases of medullary carcinoma have been mostly observed on the ventricular bands, the ventricle of Morgagni, and the posterior commissure of the larynx. (See Plate XL.)

In my opinion, however, one based on an experience of considerable magnitude, primary cancer (either sarcoma or carcinoma) is extremely rare, and in most cases the original focus of the malignant new growth is extrinsic. This very fact has given rise to the still prevalent but nevertheless erroneous impression among the laity, as well as in the profession, that the smoking of tobacco is one of the most frequent etiological factors in the production of malignant laryngeal neoplasms. Close observation of many cases has convinced me that such growths are not excited by the local irritation of the acrid tobacco smoke acting directly on the mucous membrane of the larynx, because, aside from the boyish habit of inhaling cigarette smoke, the smoker of a pipe or cigar seldom allows the smoke to come in contact with the larynx.

Symptomatology.—From what I have already said, in the above description of intralaryngeal neoplasms, it is plain that a very few words will suffice to convey to the reader the needed additional information in regard to the clinical picture presented by a given case of either a benign or a malignant laryngeal growth.

The only appreciated, subjective symptoms are those of aphonia, dysphagia, and apnœa, all three of which may vary in degree. Thus, for example, the aphonia may vary from a slight hoarseness to complete voicelessness. As regards the dysphagia there may, in one case, be merely a slight impediment in the act of deglutition (particularly of liquids), while in another there may be absolute inability to swallow either liquids or solids (aphagia). And, finally, there may be present symptoms of difficulty of breathing, such as shortness of breath in ascending stairs or slight elevations, usually aggravated by increase in atmospheric pressure, and then frequently mistaken (without a laryngoscopic examination) for asthma; or, in a more serious case, the difficulty may amount to absolute apnœa. In such a case, as a matter of course, tracheotomy is not only indicated but should be at once performed, whether the necessary or so-called necessary instruments are at hand or not. I may add here that the operation of tracheotomy in the adult is by no means so serious and difficult a surgical procedure as it is usually supposed to be, and Fauvel, Cohen, and Seiler have all mentioned in their works the fact that it is desirable for a person suffering from any intralaryngeal neoplasm to carry with him constantly the necessary instruments for tracheotomy. This is particularly to be urged in those cases of papilloma, sarcoma, cysts, and fibroma in which, either by direct obstruction of the rima glottidis or by reflex irritation of the abductors of the cords, sudden and very serious dyspnœa may momentarily be expected to develop.

Pain as a subjective symptom is sometimes present in the benign form of neoplasms, but is always present, to a greater or less degree, in cases of malignant tumors. It is of a neuralgic, lancinating, more or less intermittent character, and is usually felt in the region of the distribution of the different branches of Meckel's ganglion. In the case of extrinsic foci of sarcomata, carcinomata, or epitheliomata, the pain is referred by the patient to the middle portion of the external auditory meatus or else to the middle or inner ear, or to the mastoid process. Tuberculous and syphilitic ulcerations, as well as foreign bodies embedded in either the tonsils or the faucial pillars, also give rise to similar sensations of pain in the same regions, but in none of these affections is the pain a severe or persistent one.

All other important points in the symptomatology have already been mentioned in the description of the different types of neoplasms of the larynx, and the local picture is so manifest to the eye of the observer, when the patient's larynx is exposed to view by means of the laryngoscope, that no further explanation is necessary. The general history of the patient and that of his family should be taken into consideration, particularly in regard to prognosis, and in doubtful cases, in which a differential diagnosis, by means of the general history, laryngoscopic inspection, or other evidence presented is apparently difficult to make, the laryngeal forceps, in the hands of the expert, can readily obtain sufficient tissue from the neoplastic formation for microscopic identification. It must be a "tyro" in the art and science of histology and microscopical technology who cannot differentiate a pathological neoplasm from sound tissue, or a benign tumor from a cancerous growth.

Prognosis.—In the case of the benign variety of laryngeal neoplasms, the prognosis, if the treatment is properly conducted, is invariably good, while on the other hand, in the case of growths of the malignant cancerous variety, no matter how the treatment may be conducted, the prognosis is always bad; but life may be prolonged by early tracheotomy or thyrotomy or even by partial or total laryngectomy.

Treatment.—"A tumor is a tumor, according to Hippocrates, the father of medical lore, and as such is a superabundance of tissue; a neoplasm is a new growth and as such is too much and thereby forms a tumor" (Samuel Gross).

I do not know that I can better express my opinion or indicate my treatment regarding laryngeal neoplasms or tumors, whether benign or malignant, than to follow the precepts of my venerable teacher, Prof. S. D. Gross, who emphatically impressed upon his students that no matter in what portion of the body they might find a tumor they should "take it out," adding in a more gentle voice "with the best means at command." What he meant by the last gentle reminder was simply that no matter what wonderfully constructed instruments may be available, no matter how advantageous, in the mind of the constructor, a certain form, bend, or shape, of the instrument devised by him for a particular purpose might be, it still remains for the surgeon to have acquired the manual skill to manipulate a given instrument, and to exercise his faculty as an engineer to select the proper instrument or tool for a given case. It therefore matters little whether we use this, that, or the other celebrated authority's forceps, snare, guillotine, or what not, provided that we know, not only how to handle dextrously a given instrument, but also how to adapt ingeniously and adroitly any instrument to a given case.

Carl Seiler.

LARYNX, DISEASES OF: PERICHONDRITIS.—Perichondritis laryngea is an inflammation of the perichondrium which is prone to proceed to suppuration and to necrosis with exfoliation of the underlying cartilages. Suppuration, however, is not an invariable consequence, for resolution may occur or hyperplasia continue indefinitely.

Etiology.—*Primary acute idiopathic perichondritis*, which is rare, may be ascribed to "cold" and vocal abuse, but only in the sense that these conditions act as factors which predispose to infection by pyogenic microorganisms. It may arise by continuity of tissue in

EXPLANATION OF
PLATE XL.

EXPLANATION OF PLATE XL.

FIG. 1.—Encephaloid Carcinoma, Originating from Left Ventricle, Vocal and Ventricular Bands. Male patient of fifty-five years. Eleventh month of the disease. Death from exhaustion during twenty-ninth month of disease and one month after tracheotomy. (Case of Dr. Ethelbert Carroll Morgan, and analogous to one recorded by Fauvel.)

FIG. 2.—Encephaloid Carcinoma, Forming a Large Tumor Covering the Superior Laryngeal Orifice. (After Fauvel.)

FIG. 3.—The Same Larynx after Extraction and Destruction of the Tumor by the Galvano-cautery. The ventricular bands and left arytenoid are much swollen. (After Fauvel.)

FIG. 4.—Encephaloid Carcinoma. (After Browne.)

FIG. 5.—Encephaloid Carcinoma, Involving Larynx and Œsophagus. (After Fauvel.)

FIG. 6.—A third Instance of Encephaloid Carcinoma. (After Fauvel.)

FIG. 7.—Epithelial Carcinoma, Right Side of Larynx. (Patient examined by Dr. Morgan.)

FIG. 8.—Round-celled Sarcoma of Right Vocal Band. Patient aged forty; male. (Case of Dr. Morgan.)

FIG. 9.—Spindle-celled Sarcoma of Left Ventricular Band and Arytenoid. (After Poyet.)

FIG. 10.—Round-celled Sarcoma, Sixteenth Month, Destroying Epiglottis and the Adjacent Tissues.

FIG. 11.—Encephaloid Carcinoma, Involving Posterior Laryngeal Wall, Left Arytenoid, Aryepiglottic Fold, and Œsophageal Entrance.

FIG. 12.—Myxosarcoma, Originating from the Anterior Commissure of the Vocal Bands, Causing Great Dysphonia and Orthopnœa.

CARCINOMA AND SARCOMA OF THE LARYNX.

phlegmonous laryngitis, abscess of the larynx, and suppurative inflammation in the cervical glands and tissues. It may be due, in either an acute or a chronic form, to rheumatism, gout, or the condition termed arthritis deformans, eventuating then especially in crico-arytenoid arthritis which is unlikely to suppurate.

Acute traumatic perichondritis may be occasioned by blows, wounds, throttling, bruising by high collars, the impaction of foreign bodies in the larynx or œsophagus, or the unskilful passage of intubation tubes and œsophageal bougies. A prolonged recumbent position, especially in old and poorly nourished persons, occasionally results in decubitus by pressure of the cricoid cartilage upon the spinal column. The aged are also subject to a sort of spontaneous perichondritis in connection with calcareous changes in the cartilages.

Secondary perichondritis is more frequent. It occurs in an acute form during the course of septic and continued fevers, especially typhoid fever, smallpox, and diphtheria. It may either be preceded by ulceration, through which infection by pyogenic germs occurs, or it may represent a metastasis of the specific infecting organism. Typhoid bacilli are usually found in the necrotic cartilage in typhoid-fever cases, and it has been shown that they alone are capable of producing suppuration, but it is probable that they act usually in conjunction with pyococci.

The most frequent of all forms of perichondritis are those which are secondary to syphilis, tuberculosis, and carcinoma. Though often commencing in an acute manner they usually eventuate in a chronic process. The infiltration of syphilis may attack directly the cartilages and perichondrium, and tuberculous arthritis analogous to the white swellings of the larger joints is a possibility, but usually ulceration of the soft parts serves as an intermediate cause, providing an opening through which infection by pyococci takes place.

Pathology.—In acute perichondritis there occurs a purulent infiltration of the perichondrium whereby it is separated from the underlying cartilage; and this, involving also the overlying soft parts, constitutes a perichondritic abscess or swelling, which according to the layer affected may project externally or into the lumen of the larynx. The abscess may reach considerable dimensions before rupturing provided its discharge has not been facilitated by previous ulceration. Necrosis of the underlying cartilage and exfoliation of small or large sloughs may eventually ensue. If the perichondrium and part of the cartilage remain reproduction may take place. A fistula is apt to persist. In rheumatic cases the exudation usually proceeds to resolution and absorption without suppuration. The author has observed the same fortunate termination in syphilitic cases under vigorous antisyphilitic treatment. In typhoid fever and other cases extensive ulceration may follow the rupture of the abscess. Œdema is a prominent feature of tuberculous perichondritis as well as of the syphilitic form of the disease. It helps to impede the movements of the larynx, and is liable to culminate suddenly in dangerous occlusion of the rima glottidis. The cricoid cartilage is the one attacked in about two-thirds of the cases, and the arytenoid, usually affected on one side only, comes next in order. In the former case the abscess points either into the lumen of the larynx or into the œsophagus or pyriform sinus; in the latter, the opening is seen near the position of the vocal process. Instead of one there may be several openings, all discharging pus. When the thyroid is affected, the involvement is more often unilateral and internal. Extensive necrosis of this cartilage is less likely to occur because of a richer blood supply. The epiglottis being a fibro-cartilage is affected only by an ulcerative action. The tracheal rings sometimes become involved.

Symptoms.—The acute type is ushered in by febrile symptoms and local pain or discomfort, followed by dysphagia, dyspnœa, tenderness on pressure, and impairment of the voice, all varying in degree according to the cartilage and surface involved.

In the chronic type the tumefaction, though usually less, occasions similar functional disabilities, and is subject to acute exacerbation. Seated in the *cricoid*, when the sides of the cartilage are affected, the swelling projects into the lumen of the larynx, thus obstructing respiration; when the rear plate is involved the tumefaction is toward the œsophagus, then impeding deglutition. When the *arytenoid* is the seat of the disease it is liable to impede both respiration and deglutition. The crico-arytenoid joint becomes ankylosed and the vocal cord fixed, hoarseness of the voice resulting. Fixation of the cord in the median line would contribute to dyspnœa.

Affection of the *thyroid* on the inner face leads to dyspnœa but may or may not impair the voice. The most dangerous dyspnœa results from collapse of the laryngeal framework after the expulsion of the greater part of the cricoid cartilage. Wherever seated, the pus is liable to burrow, discharging through fistulæ which may open either within the throat or upon the neck. The sequestrum serves to maintain suppuration until exfoliation occurs, a process which unassisted may require months or years, depending upon the size and position of the sequestrum.

In *typhoid fever* the onset is usually rapid, although slight hoarseness and dysphagia may have been perceived for some days. The suffocative attacks once commenced recur at shorter intervals and are more and more terrible until tracheotomy becomes necessary to prevent a fatal termination.

Laryngeal Image.—Arytenoid perichondritis causes a unilateral pyriform swelling, or even if it is bilateral the tumefaction is not exactly symmetrical. There is immobility of the cartilage and the œdema extends along the aryepiglottic fold. The necrotic cartilage will sometimes be seen to project from the abscess opening. After exfoliation there is a corresponding depression of the part. When the inner surface of one side of the cricoid cartilage is affected there will be a bulging beneath the vocal cord, perhaps extending around the posterior laryngeal wall, and this condition is often combined with tumefaction of the arytenoid. A swelling in the pyriform sinus or in the laryngo-pharynx indicates involvement of the outer surface of the cricoid. The appearance of an abscess under the anterior commissure indicates a perichondritis of the inner surface of one or both plates of the thyroid cartilage, in which position tuberculous ulceration is the usual cause.

Diagnosis.—In the acute type the diagnosis is based upon the laryngeal aspect and the exclusion of other acute inflammatory affections of the larynx. The tumefaction of perichondritis is unilateral or at least is not equally bilateral, and is irregular and asymmetrical in outline. In œdema of the larynx and acute phlegmonous laryngitis the puffiness of the parts is usually symmetrical, and in laryngeal diphtheria there is an exudate.

In chronic cases, especially those secondary to syphilis, tuberculosis, and carcinoma, the perichondritis is apt to be obscured by the infiltration and ulceration incident to the primary disease. A fistula discharging pus, a swelling corresponding in location to the cartilages affected, and ankylosis of the crico-arytenoid joint, are indications of perichondritis. Ankylosis resulting in a fixed position of the vocal cord is distinguished, by arytenoid swelling, from abductor paralysis of the cord. The presence of swellin gand the absence of "falling in" of the arytenoid distinguish it from complete recurrent-nerve paralysis. Additional details are given under the title, "Arthritis and Ankylosis of the Crico-arytenoid Articulation."

Prognosis.—In acute cases the danger to life from dyspnœa may require a prompt tracheotomy, without which the gravity cannot be overestimated. In typhoid-fever cases, when necrosis of cartilage ensues, the mortality is very high. The prognosis is favorable in traumatic, rheumatic, and syphilitic cases provided the nature of the disease is recognized and appropriate treatment instituted. Among these there are many mild cases in which recovery takes place without difficulty, and in the majority of severe ones the patients survive, but with

more or less damage to the larynx. The disease may run a course of several years, for exfoliation is a slow process, and meanwhile the patient is liable to exhaustion by cough, dysphagia, and general distress, so that surgical assistance may improve his chances. Naturally, the tuberculous and carcinomatous conditions are most unfavorable.

TREATMENT.—In the very early stage of acute perichondritis, cold in the form of ice slowly swallowed and a Leiter coil spread over the larynx externally, supplemented by an ichthyol ointment, tends to abort the disease. Hot sedative vapors and steam inhalants allay the pain, but are indicated only when the tumefaction is insufficient to cause dyspnœa and after tracheotomy has been performed, because, while allaying pain, they are liable to intensify the dyspnœa by increasing the swelling. Alkaline and emollient sprays serve to clear the throat of mucus. Cocaine in two- to five-per-cent. solution is of value in causing temporary retraction of the swelling, but its powers are limited. An accessible abscess may be opened by a laryngeal lancet, but if the pus collection is large and points within the larynx, care should be taken to evacuate it slowly unless a tracheotomy tube is in place. Measures which are appropriate in the treatment of the primary diseases are serviceable for secondary perichondritis, *e.g.*, potassium iodide and mercury in syphilitic cases. On the appearance of severe dyspnœa a low tracheotomy should be promptly performed. Delay involves the risk of pulmonary œdema. After exfoliation and cicatrization, the resulting stenosis of the larynx will require dilatation in the same manner as syphilitic stenosis of the larynx, or else the tracheotomy tube will need to be indefinitely retained.

W. E. Casselberry.

LARYNX, DISEASES OF: PROLAPSE OF THE VENTRICLES.—Prolapse, eventration, or hernia of the ventricles of the larynx occurs as a result of chronic inflammation of the mucosa and submucous tissue lining the ventricles of Morgagni, and is, in the majority of cases, a local manifestation, in this region, of a general chronic laryngitis. The condition is not, therefore, one of true hernia, but is rather the protrusion of inflammatory hyperplastic tissue. Such tissue cannot as a rule be replaced, and the term hernia or prolapse is a misnomer.

The first case of this kind was described by Lefferts,[1] in 1875. Following this, Zawerthl[2] published a case before the Medical Congress in Geneva, Switzerland, in 1878. Solis Cohen[3] described a case in 1882, and McKenzie and Morton[4] two other cases. Gougenheim[5] described five cases of hernia ventriculi, four of which accompanied tuberculosis. Schroeder[6] describes an interesting and instructive case and Massei[7] describes one. Since then numerous other cases have been reported, but the condition cannot be regarded as of frequent occurrence.

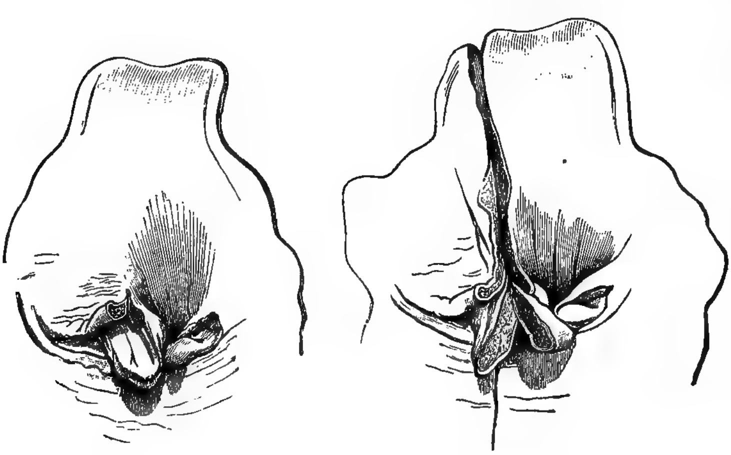

FIG. 3135.—Prolapse of the Ventricles of the Larynx. (After Schrötter.)

There are two varieties—the soft and the hard, or pachydermatous. They may be pedunculated or broad-based; they may extend but partially over the vocal cords, or may reach so great a size as to project between their free edges, and thus interfere with respiration as well as phonation. The soft variety is dependent upon stasis as the result of chronic inflammation and is, therefore, more readily influenced by treatment other than surgical. The hard variety is rarely reduced by local applications and almost invariably necessitates amputation. It is not impossible, however, for the latter variety to undergo spontaneous atrophy, but this result is by no means to be depended on if either the voice or the respiration furnishes indications for removing the mass. With the soft variety we may have considerable change in the laryngoscopic picture from time to time; the size of the tumor may also vary greatly, thus causing the symptoms to change. Thus, for example, extreme hernias are present when the tumor is enlarged from an acute exacerbation of the chronic inflammation, and there will be pronounced hoarseness. Then again, at other times, the prolapsus may be less in size, and the voice will then be scarcely roughened. This is not altogether true of the hard variety in which submucous connective tissue is greatly increased. We then have a tumor that may at times be with difficulty differentiated from a true neoplasm of the cord, of the ventricle, or of the false vocal cords. In the soft variety, again, it is not impossible to behold the prolapsed tissue disappear or diminish in size on phonation, to reappear on inspiration. This is explained by the fact that during phonation the dimensions of the sinus are increased, and the rigidity of the musculature of the vocal apparatus renders the edges of the sinus as well as its walls tense. The prolapsed tissue is thus drawn and pushed back within the confines of the sinus. During inspiration the musculature is relaxed and the area of the sinus of Morgagni is decreased, and the redundant tissue again slips down into view. The laryngoscopic picture shows a prolapse of the mucous membrane which may occupy the entire length of the ventricles, or, approaching the polypoid form, may cover a portion of the true vocal cords. The surface is smooth and of a dark red color. The disease may be bilateral or unilateral. The subjective symptoms are those of chronic laryngitis. The condition may be differentiated from true polypus, infiltration, etc., by the use of the sound; when touched with this instrument a prolapse conveys the impression of a hyperplastic or turgescent turbinated body.

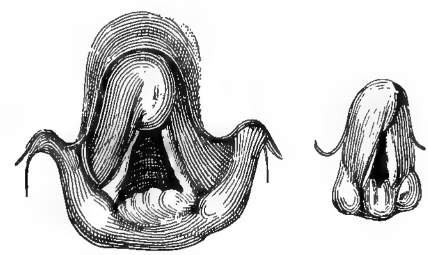

FIG. 3136.—Prolapse of the Ventricles of the Larynx. (From Heyman's "Handbuch.")

TREATMENT.—Astringents and stimulants are of little use except in rare cases of the soft variety. Destruction with the galvano-cautery is a slow and tedious process,

while the resulting scar may produce changes in the larynx which may not be without danger to the voice or to respiration. Much more rational, as Massei[7] says, is the use of either the cold or the hot snare in removing this redundant tissue. These instruments are to be used, however, by none but the most dextrous. The usual

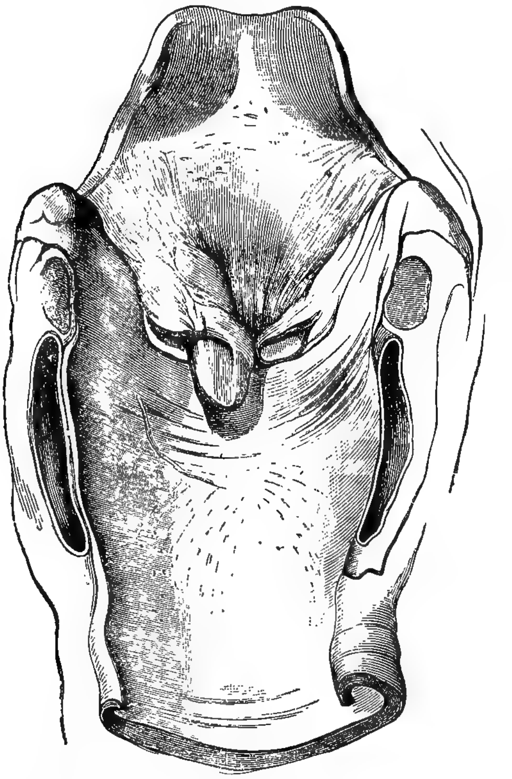

FIG. 3137.—Prolapse of the Ventricles of the Larynx. (After Schrötter.)

treatment for the chronic catarrh must be instituted and attention must be directed to the hygienic conditions surrounding the individual. Solis Cohen[3] reports good results following insufflation of sulphate of copper, and other astringents. In Lefferts' case, the performance of thyrotomy became imperative. *Norval H. Pierce.*

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LARYNX, DISEASES OF: STENOSIS.—Stenosis, as a medical term, means constriction or narrowing of an opening or tube. It may exist in all degrees, from a mere diminution of the natural calibre of an organ to complete closure. When applied to the larynx, the term implies an amount of constriction within the cavity itself sufficient to interfere with respiration. This interference may or may not be sufficient to endanger life. A very large majority of the cases of laryngeal stenosis which occur are due to conditions arising within the larynx; while the small minority owe their origin to pressure from without occasioned by external pathological conditions. The stenosis may not only be variable in degree, but variable in duration likewise; the condition being in some cases temporary, in others permanent, or at all events continuing until relieved by medical or surgical measures.

Stenosis of the larynx may be either *congenital* or *acquired.* The large majority of cases are of the latter character; while the former, or pre-natal stenosis, is so rare as to have been considered by some writers as non-existent. In the museum of the Royal College of Surgeons, London, no specimen can be found; and no less an authority than Mr. Bland Sutton asserts that: "The larynx is, of all organs, the least liable to malformation."

CONGENITAL STENOSIS.—Nevertheless, cases do occasionally occur. They may be divided into the following:

Syphilitic Stenosis.—A case has been reported by Fraenkel, in which a child three months old died of syphilitic laryngeal stenosis. Post-mortem examination revealed necrosis of the cricoid and arytenoid cartilages and the presence of intralaryngeal abscess. J. N. Mackenzie also describes a form of congenital syphilis characterized by interstitial laryngeal inflammation, and the gradual deposit of fibrous material within the organ, resulting in stenosis. This writer says that laryngeal lesions in congenital syphilis in infants are not rare, and that they have not been found more frequently, simply because they have not been sought for.

Vestibular Stenosis (Lennox Browne), caused by the presence of limp and collapsible vestibular walls. It is characterized by an approximation of the aryepiglottic folds and an excessive curling in of the epiglottis, producing more or less narrowing of the passage.

Diaphragmatic or Web Stenosis.—The most pronounced case of this class on record was reported by Sir Felix Semon some years ago. At birth the infant's cry was weak and hoarse and attended by stridor. At the age of seven years the stridor, although still present, had improved somewhat. Later on, the stridor increased again. At the age of sixteen years the larynx was examined. The movement of the vocal cords was perfect, but between the anterior three-fourths of the cords was a perfectly symmetrical, somewhat transparent, slightly reddish, triangular membrane. The free border was crescentic, considerably thicker than the rest of the web, and white in color. The remaining opening was laterally oval and less than one-third the normal size. The borders of the membrane were attached to the cords, the latter being distinguished from the diaphragm by their greater bulk and rounded form. On attempted phonation the vocal cords came almost together, and the web appeared to form a fold below their level. The voice was hoarse, almost aphonic. As the dyspnœa was increasing, operative treatment became imperative.

As a rule, pre-natal web formation is of a less formidable character, being confined to the extension of a band between the anterior portions of the vocal cords. Seifert has observed and reported a remarkable series of four of these cases which occurred in one family. In the father, aged forty-eight, healthy, a membrane supposed to be congenital was found at the anterior commissure. It was between 3 and 4 mm. in width from back to front and did not interfere with either vocalization or respiration. In one of the daughters a very large diaphragm existed, occasioning stenosis, and similar in form to the one reported by Semon. Two other daughters each had a web at the anterior commissure, though of smaller dimensions. The mother and son were both free. McKee and Lennox Browne have each reported a similar case. Chiari's case appears to be the only one recorded out of a total number of about twenty, in which the web had formed between the posterior ends of the cords.

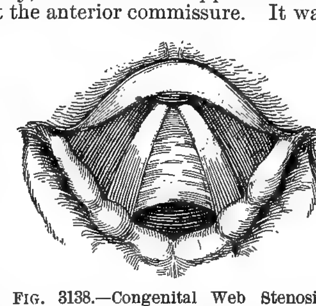

FIG. 3138.—Congenital Web Stenosis. (Sir Felix Semon.)

The congenital deformities of the posterior commissure are usually in the form of bifurcations or dilatations. Morell Mackenzie reported one in which, associated with

cleft palate, there was bifurcation of the epiglottis, extending downward as a distinct fissure between the arytenoids and the posterior surface of the cricoid. The epiglottis in this case formed two flaps which fell into the larynx. From birth there were constant symptoms of laryngismus ending in suffocation at the age of four months. A cleft in the interarytenoid region is usually the result of defective development. Congenital dilatations of the larynx in the form of pouches or laryngoceles, although very rare, sometimes occur, producing stenosis by the apparent prolapse of the ventricle.

Acquired Stenosis.—This is classed according to its cause, and may be the result of a large number of different pathological conditions. The situation may be above, between, or beneath the vocal cords; or in two or all three localities combined. There are certain symptoms common to all cases of laryngeal stenosis. All impair respiration to a greater or less degree, inspiration being usually affected more than expiration. Except in cases of acute spasm of the glottis and sudden œdema, the onset is usually slow, commencing with slight interference with normal breathing, and inspiration gradually becoming stridulous.

In cases of young children, it is often difficult or even impossible to obtain a laryngoscopic view. In these cases direct linear inspection by means of Kirstein's autoscope should accomplish a good result, by giving a direct view of the larynx without reversion, as in the use of the laryngoscope. When the view is obtained, the appearance of the larynx will be found to vary greatly according to the cause which produced the stenosis. As Asch has well said: "In œdema we have a smooth, shining swelling, differing in color according as it is produced by acute inflammation, tuberculosis, or Bright's disease. In syphilis we have a ragged, deformed, irregular larynx, sometimes filled with vegetations, and sometimes obstructed by membranous bands or adhesions. In cancer we find ulcerated masses, sanious and vegetating. In perichondritis the deformed condition of the larynx and the presence of abscess point to the nature of the disease; while the appearance of polypi and of spasm or paralysis are at once apparent on examination."

One characteristic symptom common to all cases of laryngeal stenosis is the increase of dyspnœa during the hours of sleep, owing to the fact that the crico-arytenoidei postici muscles, the dilators, are withdrawn during that period from the control of the will. As the disease advances, respiration becomes more difficult, the air supply to the lungs diminishes, and oxygenation of the blood is interfered with, until finally the face becomes cyanotic, and, to save or prolong life, tracheotomy or intubation may be called for.

While the diagnosis of the existence of laryngeal stenosis may not be difficult, the determination of the nature of the lesion which produces it in a given case may be far otherwise, calling, after the period of infantile life, imperatively for the use of the laryngoscope. If the stenosis is simply the result of contractions or adhesions, the nature of these may be readily discovered by the use of this instrument; but when excessive œdema is present, the cause is not so easily ascertained.

The principal pathological conditions which produce acquired stenosis are the following:

Neuroses.—These may be divided into acute and chronic functional, and organic.

An acute functional neurosis, in the form of spasm of the crico-arytenoidei laterales and the arytenoideus, is of frequent occurrence in child-life. These muscles, stimulated to intense activity, overcome the abductor muscles, and, preventing their normal action, interfere materially with respiration. In many cases the spasm is of temporary duration—the stridor lasting for a short period, to be followed by relief—after which the old symptoms of stenosis may recur or not, according to the character of the case. The classical laryngismus stridulus or spasmodic croup is of this nature, and while it may be very alarming to the friends of the little patient at the time, it is rarely fatal. The causes producing this condition are usually congestion or inflammation in some part of the respiratory tract, either subglottic or pharyngeal; in other cases the spasm is considered to be of a purely reflex character. Probably of the latter form were the two fatal cases of neurotic stenosis reported by Clement Hunter. These cases were so unusual that they are worth recording here. The first was that of a twin boy aged nineteen months. The other twin had died at the age of one month. The child was reported as perfectly well, when the mother lifted him out of bed to give him his regular bath. In a fit of passion he threw his head back and ceased to breathe. His face became blue and his muscles rigid. He was put into a hot bath but without avail, and died at once without uttering a sound. Two days later the sister of the boy, aged seven months, was seized in a similar manner. She had always been a healthy child. Suddenly, while lying on her mother's knee, she became rigid and blue in the face, and without uttering a sound died exactly as did her brother. In both these cases the seizure was accompanied with carpo-pedal contractions. There were no general convulsions, and in neither case had there been crowing respiration at any time. Post-mortem examination found both bodies well nourished, all the organs in a healthy condition, and neither foreign body nor obstruction in the larynx of either. There were, however, marked signs of rickets in each—a condition said to be a strong predisposing factor in the development of spasm of the glottis.

A word here in reference to the stridor of laryngeal spasm. The crowing sound so frequently heard is the sign that the spasm is either forming or relaxing, and that the air is entering the partially closed glottis. When the attack is fatal, no sound is produced, as no air can enter. When an observation can be obtained during an attack of stridor, the vocal cords will be found in a state of adduction, the niche between the parallel lines being almost absent during expiration, and presenting the form of a very narrow isosceles triangle during inspiration.

Chronic functional neurosis of the larynx may occasion a certain amount of stenosis while the neurosis continues, although it is rarely dangerous *per se.* It is a condition of general paresis of the recurrent nerve and is supposed to be occasioned by a toxic influence upon the nerve centres. In the study of the pathology of toxic paralysis of this organ arising from zymotic diseases, Watson Williams and Jobson Horne report instances in which typhoid fever, measles, rheumatism, gonorrhœa, and other affections were followed by the development of abductor paralysis, or recurrent laryngeal paralysis, when both abductor and adductor muscles were affected.

An organic neurosis of the larynx may produce stenosis. That the abductor muscles of the larynx are always more vulnerable to organic nerve lesions than are the adductors is a generally conceded fact; and many authorities go as far as Sir Felix Semon, who lays it down as a law that paralysis of the adductor is always secondary to paralysis of the abductor muscle. He summarizes this conclusion in these words: "While there is not a single authenticated case on record, in which it has been shown by post-mortem examination that, in a slowly progressive organic lesion of the motor nerves of the larynx, the adductors had been primarily or exclusively affected, we are now in possession of quite a number of well-observed cases demonstrating the opposite order of events"—that is, cases in which the abductors had been primarily or exclusively affected.

Krause has advanced what is called the spasm theory: that instead of paralysis of the abductors, it is clonic spasm of the adductors that has produced the stenosis. Regarding this theory Bosworth says that "it is difficult to understand how a clonic spasm affecting a given group of muscles can persist through a long period of years, without resulting in degenerative changes which are to an extent uniform in all; for repeated investigations have demonstrated conclusively that the abductor muscles are the ones which alone undergo marked atrophic degeneration." Hence the conclusion that they are the ones primarily affected.

Grossman combats the theory of Semon, his opposition being based upon a series of experiments; but his view, apparently, is not supported by adequate clinical investigation.

A contribution to the study of toxic paralysis of the larynx, which has also a bearing upon stenosis of that organ, is given by Heymann. It contains a résumé taken from fifty papers upon the subject. Lead poisoning is responsible for a majority of these cases. There are also instances of paralysis arising from copper, antimony, phosphorus, and arsenic, as well as from cannabis indica, atropine, morphine, and alcohol. In these cases, although there were exceptions, the abductor muscles were the ones that were in the main affected.

In support of Krause's view that the apparent paralysis of the abductors is really due to continual spasm of the constrictor muscles, Gougenheim and Solis Cohen ascribe the resulting atrophy of the dilator muscles, as reported by Bosworth, to be due to mechanical rather than to paretic immobility.

Acute œdema of the larynx is an infrequent but dangerous cause of laryngeal stenosis. It is usually sudden in its development, and may occur either as a primary disease or secondary to some other affection. It is a condition of the larynx attended by infiltration of the submucosa, due to exosmosis from the lymphatics and blood-vessels.

Primary œdematous laryngitis is exceedingly rare. Of two cases that I have seen, one only was very severe. It occurred in a man aged thirty, who was in the enjoyment of excellent health. One night, after playing billiards until a late hour, he retired feeling as well as usual. Two hours later he awoke with a sense of suffocation. From that time until daylight his doctor did what he could to relieve him, when he was driven to my office in a cyanotic and stertorous condition. I found the epiglottis and arytenoids so œdematous that neither the ventricular bands nor the vocal cords could be seen. The man was not a drunkard but had been indulging more freely than usual. Free scarification of the posterior surface of the epiglottis and the arytenoids, together with hot steam inhalations, resulted in recovery.

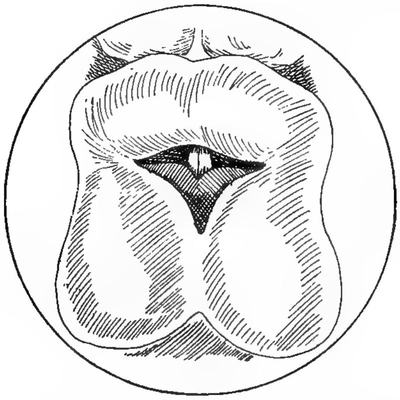

FIG. 3139.—Stenosis from Acute Œdema of the Larynx. (Bosworth.)

Œdema may be occasioned by fractures of the cartilages, by inhalations of irritating vapors, by the use of escharotics, etc.; it may be due to inflammatory action in adjacent structures, abscesses, wounds, etc.; or it may occur as a secondary effect from syphilis, carcinoma, tuberculosis, myxœdema, syringomyelia, Bright's disease, phlegmon of the peritonsillar tissue, and many other affections.

The symptoms in acute œdema are markedly laryngeal. Dyspnœa and loss of voice, with pain upon movement or upon efforts at deglutition or phonation, come on rapidly. If relief is not obtained, cyanosis, mental distress and restlessness, followed by hebetude, quickly appear; the temperature rises, and after a day or two the patient dies.

Inspection will show the epiglottis and arytenoids so swollen as to render a view of the interior of the larynx out of the question. In some cases all that can be observed by the use of the laryngoscope will be a distorted mass of œdematous tissue.

FIG. 3140.—Turban-shaped Epiglottis. (Lake.)

When the disease is less acute, and owes its origin to some chronic systemic dyscrasia, the symptoms are less alarming; and although the case may be hopeless, the condition may last for weeks without producing a fatal issue.

On examining by the laryngoscope, in the milder forms of the disease, only certain parts will be found to be seriously affected, the swelling being localized about the epiglottis, arytenoids, ventricular bands, or subglottic region, some or all of these parts being affected. Good examples of this form of œdema are pictured in Lake's illustrations of laryngeal tuberculosis. In Fig. 3140 we see a turban-shaped epiglottis; and in Fig. 3141, œdema of the arytenoids.

The color of the mucous membrane in œdema varies from a grayish-pink to a bright red; the tissues are full and rounded, and the membrane is bright and glistening. There is usually copious secretion, but this is not necessarily of a purulent character, if the mucosa has not been broken.

Pseudomembranous Stenosis.—This condition is of frequent occurence. It usually forms a complication of laryngeal diphtheria, being an extension of the disease downward from the pharynx. When the false membrane is deposited upon the laryngeal walls, it lessens the capacity of the organ, thereby diminishing the power of respiration (see article on *Diphtheria*). Sometimes false membrane has been formed within the larynx as the result of swallowing hot or caustic fluids.

Perichondritis as the result of fracture, simple or compound, will occasion stenosis of a severe character. Compound fracture is particularly likely to be fatal, probably more so than is an incised wound of the organ.

When perichondritis is the result of a specific disease, such as syphilis, tuberculosis, actinomycosis, glanders, etc., it is usually accompanied by swelling, with streptococcal, staphylococcal, or pneumococcal invasion. Purulent infiltration follows, dissecting the perichondrium from the cartilage, producing necrosis, and rapidly developing abscess formation. The result is usually extreme stenosis. In the majority of instances of perichondritis due to typhoid fever, the infection and inflammatory action are similar to those seen in abscess formation, and the pus, making for the point of least resistance, effects an opening, and there is thus established an ulcerated condition of the mucous membrane. The typhoid bacillus is usually present in the necrotic mass (Kyle).

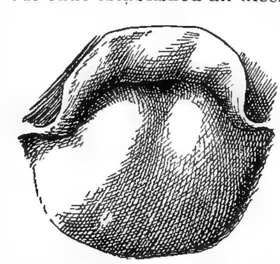

FIG. 3141.—Œdema of Arytenoids. (Lake.)

What Lake terms the acute fulminating perichondritis of tuberculosis is accompanied by all the signs of acute œdematous laryngitis with high fever and severe stenosis, demanding immediate tracheotomy; while the chronic variety produces less stenosis, as, by reason of the slower action, ulceration, exfoliation, and expectoration of necrosed cartilage follow one another in regular order.

In perichondrial abscess of the cricoid, the stenosis is most severe and the danger imminent, owing to the great swelling which occurs in this region. When several car-

tilages are involved the prognosis is most unfavorable. In nearly all cases, however, life might be prolonged if tracheotomy were performed early in the disease. The presence of a purulent sac within the larynx would preclude the advisability of intubation.

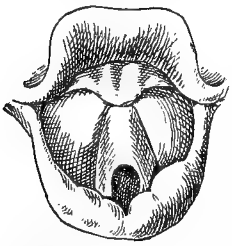

FIG. 3142.—Cicatricial Stenosis before Treatment. (Lennox Browne.)

What Gerhardt terms "*chorditis inferior hypertrophica*," owing to the fact that it is attended with local subglottic hypertrophies, sometimes occurs, and may be productive of a serious degree of laryngeal stenosis. The "*chronic blennorrhœa of Stoerck*" likewise produces hypertrophies and cicatrices, but in the vocal cords instead of beneath them. Klebs says that histologically the elements in blennorrhœa resemble those of rhinoscleroma. It is a question whether both conditions are not of the nature of pachydermia. When cicatrization takes place in subglottic hypertrophy it results in the formation of a firm white glistening membrane, sometimes completely encircling the subglottic ring of the larynx, producing more or less permanent stenosis. Cicatricial bands in blennorrhœa chronica may produce a similar result. Asch describes a case in which he found two folds of membrane, one on either side of the larynx beneath the vocal cords and on a level with the cricoid. They had so contracted the passage that the aperture was only the size of a goose quill. The breathing was stridulous and could be heard in the next room. The dyspnœa at times was so great that treacheotomy seemed inevitable. The stricture, however, was dilated with laryngeal forceps, this being followed up with further dilatation by a succession of Schrötter's tubes, and the lumen of the larynx was restored to nearly its normal size.

Cicatrices are scars left by the healing process after destruction or injury of normal tissue. Hence these can occur only when nature makes an effort to repair the organism, parts of which, either from disease or from injury, have been destroyed. The formation of scar tissue is a pathological process of a purely provisional character, the tendency after development being toward constant contraction. Consequently, when cicatrices occur in the larynx, the stenosis which they occasion is more likely to increase than to diminish.

Syphilis, when it occurs in the larynx, is, of all constitutional diseases, the one most likely to be followed by cicatricial stenosis, as is well shown in Lennox Browne's case (Figs. 3142 and 3143). This never occurs, however, in the early stages but only in the tertiary period, years after the original infection. It is then that the gummy syphilide of Fournier and deep ulceration summarily destroy the tissues, and it is nature's effort to repair the wholesale destruction that produces the cicatrization. The parts usually affected first are the epiglottis and the arytenoids. Still no region of the larynx can be considered free from the possibility of infection. The tendency is to extend gradually to the surrounding tissues. When the cartilages are partially or wholly destroyed, they make their way through the ulcerated surfaces of the mucous membrane, being discharged intralaryngeally, rarely through the external wall.

FIG. 3143.—The same after Use of Cutting Dilator. (Lennox Browne.)

Lupus also sometimes gives rise to stenosis by the formation of cicatricial tissue. The narrowing of the laryngeal lumen, due to cicatricial contraction in an old case of lupus, is characterized by a general matting together of the parts (Kyle), until the opening may be almost obliterated. There are several instances on record of this character. The tissues are usually anæmic, except when small red nodules give evidences of acute inflammation.

Leprosy of the larynx is always attended by more or less dyspnœa, stenosis of the glottis being a prominent feature whenever the larynx is attacked. Phineas Abraham reports a case in which the glottis was reduced to the size of a duck quill, necessitating tracheotomy to prolong the life of the patient.

Tuberculosis of the larynx is frequently the cause of stenosis; and may occur in several ways. Perhaps the most frequent is in the form of submucous infiltration of the epiglottis and of the arytenoids, as shown by Lake. Paralysis of the vocal cords due to glandular pressure upon the recurrent nerve is of not unusual occurrence. Hyperplastic formation within the larynx, immobility of the arytenoids from ankylosis of the articulation, granulomata, and papillomata, may any of them so lessen the lumen of the larynx as to produce stenosis. It may be safely said, however, that cicatricial stenosis rarely if ever occurs in tuberculosis of the larynx. The whole tendency of the disease is toward destruction. Repair after surgical measures does sometimes occur, but the prior destruction in these cases has never been so great as seriously to lessen the size of the cavity after the process of healing was accomplished.

Glanders sometimes attacks the human subject (Asch), and when it does the larynx is often affected. Simultaneously with the development of tubercles and ulcers in the respiratory tract, infiltration takes place in the laryngeal mucous membrane. Secondary œdema may give rise to dyspnœa; and, when healing occurs, contraction of cicatrices may give rise to severe and permanent stenosis.

Leucocythæmia.—Otto Barwick and Eppinger throw new light upon the pathological condition of the larynx induced by this disease. In the parts rich in glands, especially the epiglottis and false cords, catarrh occurs with swelling of the mucous membrane. Small lymph tubercles may form throughout the lining membrane of the larynx, and the tops of these may ulcerate. White blood cells accumulate in large numbers in the blood-vessels; and the characteristic infiltration takes place in the form of small islands, which have been termed leukæmic infarctions. When the tubercles or nodules are in exposed parts, they readily break down by ulceration and hemorrhage occurs from them. The most important of the clinical features is the laryngeal stenosis, which the diffuse leucocythæmic infiltration sometimes produces. In some cases this infiltration comes on very rapidly and is followed by death from dyspnœa in a few weeks.

FIG. 3144.—Stenosis from Multiple Papillomata. (Grünwald.)

Gout is sometimes the cause of serious spasm of the larynx. Watson Williams reports a case in which the patient would be attacked by indigestion and gout whenever he was indiscreet in diet. The gouty attacks always came on in the night, assuming the form of laryngeal spasm. Allbutt has also recorded a similar case.

Benign tumors of the larynx give rise to more or less stenosis, according to their character and location. They rarely in the adult attain a size great enough to endanger life, although the involvement may be sufficient materially to impede respiration. Of all forms of neoplasm which occur in this region papillomata are the most frequent. They occur at all ages. In adult life they are usually discrete or single, and although they may give rise to serious symptoms, they are rarely the cause of severe stenosis. Multiple papillomata, on the other hand, occur most frequently in young children, sometimes studding the vocal cords and the whole interior of the larynx, and seriously interfering with respiration. Some authorities look upon the presence of adenoids in

Larynx.

the naso-pharynx as the chief cause. Quinlan says that in thirty-one cases of papillomata in children and young adults, he found adenoids in all but three. The contact of the dry and often dusty atmosphere with the tender mucous membrane of the larynx, in cases of mouth breathing, is supposed to be the irritating cause of the formation of these growths. Many authorities give over fifty per cent. as the proportion which papillomata bear to all other neoplasms of the larynx, including both the benign and the malignant forms. Next in frequency come fibromata. They occur singly, as also do myxomata, fibro-myxomata, angiomata, lipomata, adenomata, and cystomata. The two latter are exceedingly rare. The symptoms produced by all these growths are very similar, varying according to the size and position of the neoplasm. It takes a larger growth to produce stenosis in the supraglottic than in the infraglottic region; while tumors situated upon the vocal cords, although smaller than in the localities mentioned, are much more likely to produce spasmodic stenosis.

The discovery of the neoplasm can be made only by the use of either the laryngoscope or the autoscope; and the nature of the growth, in many cases, can be learned only by microscopical examination of a minute section of the same.

The prognosis in benign growths is rarely unfavorable. They can usually be removed by endolaryngeal methods; and in the cases of multiple papillomata of children, which bear so large a place in the sum total of cases, the lesions will shrivel and exfoliate or be absorbed, when surgical measures relieve the mucous membrane of the larynx of the irritation caused by the inspired air.

Malignant neoplasms may occur in different types, all being histologically the same as when found in other organs of the body. The usual form in which cancer occurs in the larynx is either epithelioma or encephaloma. Scirrhus and sarcoma are more rare. Encephaloid cancer is rapid in its development, and causes stenosis by filling up the interior of the larynx with an irregular, mammillated, light rose-colored, fungous mass. Epithelial cancer is slower in growth, but, like the former, difficult to diagnose. In early stages it resembles a large and irritable papilloma. One distinguishing feature in nearly all malignant growths is the formation of glandular enlargements in the submaxillary and cervical regions.

The principal laryngeal symptoms, as in the case of benign growths, are the gradual loss of voice and the presence of increasing laryngeal stenosis; but accompanied by more pain and fetor. The diagnosis will depend on the physical symptoms together with the results of laryngoscopic and microscopic examination. When visible lesions become apparent, they are not always easily distinguished from syphilis, and may require constitutional treatment for differentiation. With tuberculosis it is not so likely to be confounded. Microscopical examination of a small piece of growth should remove all doubt, although W. N. Mackenzie condemns a resort to this means of diagnosis, as too hazardous to the patient. As the disease advances, vegetative hypertrophies fill up the larynx, become more observable, and render the diagnosis more certain. The prognosis is always bad, the patient dying from one to several years after the inception of the disease, and not infrequently from asphyxia the result of the stenosis.

Foreign bodies within the larynx may by their presence produce stenosis. A number of such cases have been recorded in which relief was obtained by their removal, while in other cases the lesion caused by the foreign body, notwithstanding its removal, has been followed by stenosis. Bruggisser reports the case of a man, aged twenty-four, in whose larynx a rubber plate containing two false teeth was impacted. This was removed on the eighth day, but the removal was followed by complete abductor paralysis, and tracheotomy had to be performed to relieve the stenosis. Kiser relates the case of a man who died of laryngeal and pulmonary tuberculosis. He had suffered much from stenosis. On post-mortem examination, a tooth was found in the distended ventricle of Morgagni. It had probably fallen into the larynx after extraction and had been coughed into the ventricle. Its presence may have been the primary cause of the fatal disease.

Stenosis from External Causes is due to compression upon the larynx from without. The most common cause is goitre, particularly the enlargement of the central lobe or the isthmus of the thyroid gland, a condition that frequently obtains in exophthalmic goitre. In some cases the stenosis from compression is so great that the

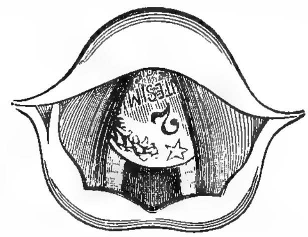

Fig. 3145.—Coin in Laryngeal Ventricle. (Grazzi.)

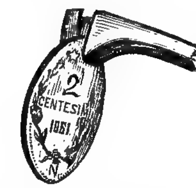

Fig. 3146.—Coin in Grasp of Forceps; Showing Method of Removal. (Grazzi.)

recumbent posture has to be abandoned and the sitting one assumed even during sleep. Abscess, aneurism, enlarged tuberculous glands, or neoplasms in the region of the larynx may produce compression upon the larynx sufficient to induce stenosis. In some cases the extension of portions of the morbid growth to the interior of the larynx has aided much in producing the stenotic result.

Treatment.—*In congenital diaphragm-formation,* when stenosis is severe, operative treatment becomes necessary, to save life as well as to give voice to the patient. One characteristic of the web which connects the anterior portions of the vocal cords in these cases, is its great toughness and the impossibility of cutting it *in situ* with a knife. In Kreig's case attempted incision of the web was followed by so much œdema that tracheotomy had to be done. In Seifert's case the knife broke when he was trying to cut with it. In Greenfield's and also in Semon's cases it was impossible to cut the membrane with the ordinary laryngeal knife; but Morell Mackenzie was able in his case to excise the membrane with scissors. Sir Felix Semon after cocainization punctured the membrane with the electro-cautery. To his surprise the result was satisfactory, and he repeated the process, at intervals, several times. The tissue gradually shrank away, leaving the cords clear; and to complete the operation, he removed the remaining segment of the web at the anterior commissure with cutting forceps. His patient made a good recovery without any return of the web formation. The diaphragm, in these cases, is usually thickest at the anterior or acute end. The condition is so exceedingly rare that each individual case must be treated on its merits, guided by the judgment and laryngeal experience of the operator.

In functional stenosis, particularly laryngismus stridulus of childhood, induced by irritation of the nerve centres, the rapid production of counter-irritation or peripheral shock will often give relief. Dashing cold water in the face or hot water on the nape of the neck, traction on the tongue made at respiration intervals, immersion in a hot bath, or the application of sinapisms to the anterior or posterior surface of the neck may be useful. Nerve sedatives may also be indicated—such as chloral hydrate, bromide of potassium, chloroform, or nitrite of amyl. When catarrhal laryngitis is the cause, aconite, tartar emetic, pilocarpine, or apomorphine may in appropriate doses prove of benefit; while placing the patient in a steam atmosphere of a uniform temperature should aid materially in putting an end to the spasm. Should the stenosis be severe enough to threaten life, as in the cases recorded by Hunter, intubation should be resorted to at once. The difficulty lies in not always being able to secure the necessary instrument in time to save life.

As children thus affected are often of a rachitic diathesis, the general system during the intervals between attacks should be carefully examined into, and appropriate treatment administered. Iron, hypophosphites, and codliver oil may any or all of them be indicated.

Organic stenosis arising from paralysis of the abductor muscles will be urgent in its call for treatment according to whether the disability is unilateral or bilateral. When of central origin, whether from the effects of tertiary syphilis or from those of neoplastic pressure upon the nerve centres, iodide of potassium, in large doses pushed to the verge of tolerance, may be of benefit. In certain cases treatment by electricity serves a good purpose. We may use either the faradic or the static current, although in the majority of cases the galvanic current has proved the most useful. One of the electrodes should always be placed within the larynx upon the vocal cords. In threatened suffocation from complete bilateral abductor paralysis, Krause has suggested section of both recurrent laryngeal nerves; by this means throwing both vocal cords into the cadaveric position, relieving the dyspnœa, and prolonging the life of the patient, but destroying the voice.

Acute Œdema of the Larynx.—Prompt and energetic treatment is in these cases called for. The œdema needs immediate relief. If possible the patient should be confined to a room with the air surcharged with moisture at a temperature of 72° to 75° F. At the same time an ice bag may be applied to the neck and retained there—if the condition of the patient warrants it—until relief has been obtained. In some cases heat constantly applied to the neck will be attended with equally good results. As directly local treatment, free scarification of the œdematous mucous membrane should be at once resorted to. The efficiency of the latter will be enhanced by the constant respiration of warm saturated air. Together with the above, cathartic and antifebrile measures may aid in hastening a recovery. Acute œdema of the larynx is a disease in which intubation can scarcely be called for, as the tube after insertion lies at a lower level than the œdematous swelling. In cases in which the stenosis continues, tracheotomy may be required.

Pseudomembranous Laryngeal Stenosis.—As this condition is associated with diphtheria, the reader is referred to the article on that disease for more detailed information. There are practically only two methods of treatment, viz., the administration of successive doses of antitoxin, and intubation or tracheotomy; or, what is perhaps more frequent, the combined use of antitoxin and intubation. In my own practice I may say that formerly when, in consultation, I did intubation alone for the relief of diphtheritic laryngeal stenosis nearly all the patients died. Now, as in every instance antitoxin is used as well as intubation, the large majority of the patients recover.

In cases, however, in which the pseudomembrane is of a traumatic origin tracheotomy will be preferable to intubation. I have seen one case of this kind. A young child inhaled steam from a boiling kettle. Œdema and false membrane formed at once in the pharynx and presumably in the larynx. The voice became inarticulate, and five hours after the accident the child became cyanotic from laryngeal stenosis. Tracheotomy gave immediate relief. The tube was worn for a week and the child recovered.

Perichondritis.—When the disease has gone to the extent of intralaryngeal abscess, it is usually accompanied by œdema, particularly if located in the subglottic region, and tracheotomy may be the only resource. When the perichondritis is above the cords, affecting the arytenoids or the epiglottis, the swelling may not be so great; and the use of astringent and antiseptic sprays may be of service. In chondritis or perichondritis of syphilitic origin, constitutional treatment should be resorted to, the iodides being preferred. If stenosis becomes urgent enough to demand surgical measures, tracheotomy should be preferred to intubation, for prolonged intubation diminishes the possibility of effective feeding, while tracheotomy does not.

Cicatrices.—One of the chief dangers of scar tissue in the larynx is due to its constant tendency to contract, thus producing steadily increasing stenosis. In cases of syphilitic laryngitis systemic treatment with iodides and mercury would minimize the destructive action of the disease and lessen the danger of subsequent stenosis; but when the latter exists, from the presence of bands actually formed, relief can be obtained by dilatation. It is better, however, to incise the bands and then dilate or use an instrument such as Whistler's or Lennox Browne's, either of which will perform the double duty of incision and dilatation at the same time. Schrötter advises tracheotomy first, and then the use of dilators in gradually increasing size. Störck uses a dilator attached to the upper portion of a tracheotomy tube, distention of the constriction being thus made from below, without the passage of any instrument through the mouth. Navratil has invented an instrument for rapid dilatation. The great danger, after dilatation, in all cases of scar-tissue stenosis, whether the cicatrices have been incised or not, is that of recurrence. To aid in the prevention of this, iodides should be administered and a judicious oversight of the patient retained.

Benign Neoplasms.—When stenosis is occasioned by the presence of benign neoplasms their partial or complete evulsion may be required. Evulsion is not, however, in these cases a hard-and-fast rule. While many authorities have advocated and practised thyrotomy and subsequent evulsion, and also removal by intralaryngeal methods, in papillomata of children, other recent writers have advocated tracheotomy and the wearing of a tracheal tube, as the more successful method of treatment—leaving the papillomata severely alone. In Railton's case of multiple papillomata, tracheotomy was done at the age of three and one-quarter years, and at the end of the first week, the metal tube was replaced by a soft one. This was removed twice a week to be cleansed, and worn for three and three-quarter years, to be finally discarded at the end of that time, the child being cured. Hunter MacKenzie has written a long article upon the subject, recommending this as the radical method of treatment, in which he is indorsed by such men as Garel, Oertel, Eliasberg, White, Chappell, Gleitsman, Baumgarten, and Carmichael.

Except in cases of papillomata of children, benign neoplasms are rarely multiple, and when laryngeal stenosis is produced by their presence intralaryngeal evulsion when possible should always be practised. This may be accomplished by the use of snares, cutting forceps, knives, or the electro-cautery, under the influence of cocaine. Care should always be taken lest the occurrence of hemorrhage complicate the operation; and preparation should be made to meet the emergency by tracheotomy if necessary. In some cases the growth can be removed by thyrotomy.

Malignant Neoplasms.—When the neoplasms producing stenosis are of a malignant character, attempted relief by evulsion is almost out of the question. Only when they are pedunculated, which carcinoma rarely is, and attended by no glandular involvement, should this ever be attempted. Fraenkel reports a case in which an epithelial growth was removed successfully from the right vocal cord by the galvano-cautery snare, although he had to repeat the operation a number of times at intervals of several months before the disease was finally arrested. I believe this is the only case on record of complete and lasting recovery from epithelioma of the larynx by intralaryngeal operation. When the tumor is large enough to produce stenosis, and, while unattended by glandular disease, is still confined within the larynx, removal of the whole of the organ by thyrotomy is considered warrantable, tracheotomy having first been performed. As a rule, however, the only relief in these cases that can wisely be given is that of the latter operation, which grants freer respiration, nature being left to do what she can with the offending neoplasm. Intubation in malig-

nant stenosis of the larynx is not advisable, as it would only increase the irritation by pressure upon the malignant growth.

External Compression.—The treatment of stenosis arising from external pressure depends upon the nature of the compressing body. Probably goitre is the most common cause of this condition, the isthmus or middle lobe being in certain cases so hypertrophied as to compress seriously both the larynx and the upper rings of the trachea. Relief in these cases may sometimes be accomplished by the administration of large doses of thyroid extract. Thymus extract has also found its advocates. In other instances a portion of the isthmus or a lateral lobe of the thyroid has been removed, this being followed by relief of tracheal and laryngeal pressure. The removal of the whole of the thyroid is not advisable as it might stimulate the development of myxœdema.

Sometimes the pressure, upon the larynx, of a posterior or lateral pharyngeal abscess has produced stenosis. Peritonsillar abscess has been known to extend down the sheath of the pharyngeal muscles to the arytenoid region and, interfering with circulation, to induce œdema of the larynx, with the same result. In like manner abscess of the lingual tonsil may induce œdema of the epiglottis and seriously interfere with respiration. In all these cases giving free vent to the retained pus by incision, either externally or internally, as the merits of the case may demand, should afford relief, and, by removing the pressure, restore the sympathetic condition of the larynx to its normal state.

When benign external neoplasms interfere with respiration, they should be removed by ordinary surgical methods, while malignant growths pressing upon the larynx demand low tracheotomy as the one measure likely to afford relief and prolong life.

This brief survey of the main causes of laryngeal stenosis, and the principal methods of treatment now in use, while not by any means complete, will give a fair idea of the means at our disposal for dealing with this distressing class of cases. No exact set of rules can be laid down. Each individual case must be treated on its merits; and the surgeon having become familiar with the technique required, should grant to his patient the most practical as well as the most scientific treatment at his command. It should be remembered also that, to obtain the best results, a large share of unwearying patience and perseverance is often required. *J. Price-Brown.*

LARYNX, DISEASES OF: SYPHILIS.—The period from the primary infection to the development of general infection, as evidenced in the larynx, varies from eight weeks to three months, but the latter may occur as late as twenty or even thirty years after the primary inoculation. Primary syphilis of the larynx is an extremely rare condition, only two cases, so far as the writer has been able to discover, having been reported—one by Krishaber in 1877, and the second one by Moure in 1890. The lesions met with in acquired laryngeal syphilis are, therefore, of the secondary and tertiary type, and concomitantly with these there are frequently cutaneous lesions corresponding to each period. The larynx, from its liability to various forms of catarrhal trouble, is especially apt, on account of its thus lowered resisting power, to show lesions of syphilis. From the frequency with which they are exposed, through the variety of occupations of life, to catarrhal conditions of the respiratory passages, men—as it appears from a review of the statistics of numerous authors on this subject—are more liable than women to have syphilis of the larynx. The question of relative frequency of secondary or tertiary laryngeal manifestations is variously stated by different authors. In the writer's experience the tertiary manifestations have been the more frequent. There is no relation between the character of either the primary or the secondary manifestations and the subsequent tertiary symptoms. In a few cases neither the physician nor the patient himself has been able to detect any evidence of primary infection, and even secondary manifestations may not be noticed; and the only evidence one has that a former infection has occurred is the presence of extensive tertiary ulceration.

Objective Symptoms.—The lesions which manifest themselves are of the secondary and tertiary stages. The most common lesions of the secondary stage are: (1st) erythema; (2d) superficial ulceration; (3d) a mucous patch, and (4th) condylomata.

Upon laryngoscopic examination the mucous membrane will either be found to be uniformly hyperæmic, thus presenting essentially the same appearance as that of an ordinary acute laryngitis, or it may show an irregularity in the distribution of the inflammatory areas, this irregularity being due to interposed areas which are non-vascular, and the whole picture presenting a so-called mottled appearance which, as some authors maintain, is definitely characteristic of secondary syphilis.

The areas involved in the inflammatory process are generally the epiglottis, the false and the true cords. In cases in which the inflammation is uniformly distributed and persistent, its specific nature may be inferred from the fact that it does not yield to anything but definite antisyphilitic treatment. This inflammatory process may lead to a destruction of the superficial layer of the mucous membrane, in which case there will then be seen a small, shallow, and irregularly shaped ulcer whose surface is covered with a yellowish-colored secretion. The superficial ulcers may extend and unite with others, and when healed leave a very thin, stellate-looking cicatrix.

The occurrence of the mucous patch within the larynx is doubted by many, and yet, on the other hand, there are some who believe that it occurs frequently in this locality. As a feature of secondary laryngeal syphilis it evidently occurs with comparative rarity. In appearance the laryngeal mucous patch is similar to that which occurs in the mouth; there is a thickening of the mucous membrane, rounded, oval or oblong in outline, of a whitish-gray or yellowish color, and surrounded by an area which is markedly hyperæmic. The surface of the patch may be either elevated or depressed. The localities where such a patch may be seen are the laryngeal surface of the epiglottis and its edges, the aryepiglottidean fold, and the false and true cords. This lesion is generally associated with the earliest syphilides.

Condylomata in the larynx appear as rounded or oval elevations with a yellowish-colored surface; they seem like aggregated mucous patches. Whistler has called attention to a relapsing ulcerative laryngitis, which marks an intermediary stage between the secondary and the tertiary forms, and is characterized by a loss of substance of the mucous membrane neither so extensive nor so deep as that which occurs in the tertiary form. This ulceration attacks, in order of frequency, the vocal cords, the interarytenoidean space, and the false cords.

Tertiary Syphilis manifests itself in the three forms of a gumma, an ulceration, and cicatricial tissue. These conditions exhibit themselves in succession within a period varying from three to twenty or more years after primary infection.

The gumma presents itself as an infiltration, varying in size from that of a very small pea to a size sufficient to produce obstructive symptoms. In appearance the mucous membrane covering it may be normal or of a darker hue, elevated above the surrounding mucous membrane, and its base presenting an area of inflammation of a deep rose color. It may be found on the laryngeal surface and edges of the epiglottis, the aryepiglottidean folds, the interarytenoidean space, the false cords, and the subglottic region. The gumma is usually single but may be multiple. With the progress of time the gumma undergoes a retrograde metamorphosis, as a result of which it becomes yellowish in color and at last breaking down, presents the stage of *ulceration.*

The ulcer thus formed has generally a circular outline, edges which are ragged and thickened, a surface excavated and covered with a dirty yellowish-colored secretion, and a base displaying a zone of hyperæmia. The ulcer is usually single, but sometimes there are

several of them, corresponding to the areas previously occupied by gummata. If neglected the inflammatory process may extend to the deeper-lying structures, and a perichondritis with subsequent abscess formation, necrosis of the cartilage and its exfoliation, may ensue. Perichondritis may, however, occur without ulceration. It is in this stage of ulceration that dangerous symptoms are apt to supervene. An œdema, either acute or chronic, may arise and produce symptoms of marked dyspnœa; or the exfoliated cartilage may obstruct the respiratory tract, or the loss of the cartilage—especially if it be a portion of the thyroid, cricoid, or arytenoid—may lead to such collapse of the larynx proper as very materially to interfere with respiration. The epiglottis may be involved to such an extent as to interfere with the process of deglutition and allow portions of food to enter the larynx. Fixation of one or both vocal cords, as a result of a perichondritis or chondritis, may lead in some cases to a narrowing of the rima glottidis and its consequent dyspnœa. Myopathic paralysis of the abductors is not of common occurrence but of very serious moment when present. Finally, hemorrhage may occur and may even result fatally, but, fortunately, this happens rarely.

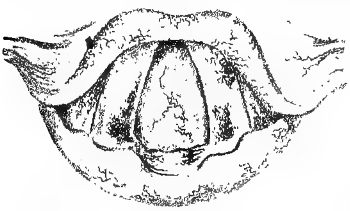

FIG. 3147.—Acute Syphilitic Laryngitis. (Türck.)

The final step of the tertiary stage is that of cicatrization. The result of a healed syphilitic ulcer may present itself in many forms. The less extensive cicatrization is evidenced by a white stellate scar of varying extent. The results of ulceration and cicatrization of adjacent structures often lead to the epiglottis being bound down to the base of the tongue, or to the posterior or the lateral walls of the pharynx. Bands may be stretched across the lumen of the larynx and by their contraction lead to great distortion of its structures. Again, adhesions between the vocal cords may result in web-like bands which may involve the glottis to a greater or less degree. The cicatricial process may be so severe as simply to convert the larynx into a mass of cicatricial tissue with a small perforation in the centre acting as the glottis.

SUBJECTIVE SYMPTOMS.—In the secondary stage the subjective symptoms are usually those of a severe acute laryngitis: the voice is husky and even aphonic, there is moderate cough with expectoration of a small amount of tenacious secretion, and, if the epiglottis be involved, deglutition may be painful. In the tertiary stage the symptoms are more pronounced. The alteration in the character of the voice varies from a slight huskiness to complete aphonia. Dysphagia is apt to be a more frequent symptom in this than in the secondary stage, owing to the involvement of the epiglottis in the inflammatory and destructive processes. Occasionally food finds its way into the larynx when the epiglottis is involved in the destructive process, but it is astonishing how readily patients in whom the epiglottis is totally destroyed learn to swallow without food entering or obstructing the larynx.

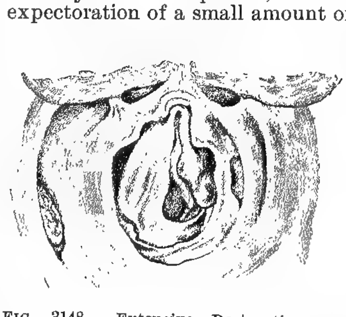

FIG. 3148. — Extensive Destruction and Cicatrization of the Epiglottis; Involvement of the False and True Vocal Cords; Stenosis of the Pharynx from Adhesion of the Epiglottis to the Root of the Tongue and Posterior and Lateral Walls of the Pharynx. (Türck.)

It is in the tertiary stage that sudden œdema is apt to supervene, and it may produce such grave symptoms of stenosis as to necessitate immediate tracheotomy. When a suppurative process is going on in the larynx there is apt to be marked general disturbance, the temperature rising to 102° or 103° F. Externally, the perichondritis or suppurative process may be marked by swelling and tenderness over the affected part, and with destruction of the cartilage and its exfoliation there is always danger of the exfoliated portion obstructing respiration. The breath, when the disease has reached such a stage, is usually very offensive; the expectoration is muco-purulent in character, sometimes tinged with blood, and it may contain fragments of necrotic tissue.

DIAGNOSIS.—It is the diffuse laryngitis of the secondary stage that alone requires differentiating from the non-specific acute catarrhal laryngitis. Objectively, there may be at times, and especially when the inflammation is uniformly disposed, considerable difficulty in deciding which of the two conditions one has to deal with. Under such circumstances it will be found that the non-specific form of laryngitis will yield to the usual methods of treatment, whilst one should always be suspicious of a laryngitis which resists such treatment. A laryngitis which occurs in a tuberculous subject may also resist local treatment, but in this case there are marked pallor of the soft palate and an irritable condition of the posterior wall of the pharynx, and a careful examination of the patient's general condition and of the sputum will very materially aid in clearing up the diagnosis. It is, however, more in the ulcerative form of the disease that difficulties of diagnosis present themselves; the diseases from which syphilis of the larynx in this stage requires to be differentiated, being tuberculosis and carcinoma.

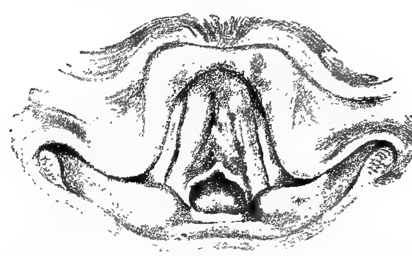

FIG. 3149.—Membranous Adhesion Between the True Vocal Cords. (Türck.)

In tuberculosis the ulcers are apt to be numerous, the outline not so sharp or distinct, the edges less indurated, the surface not so deeply excavated, and the granulations pale and indolent-looking; the mucous membrane of the soft palate, pharynx, and larynx is distinctly pale; there is some general febrile disturbance ($99\frac{3}{5}$° to 101° F.) with increased rate of pulse; and the general appearance of the patient is commonly that of a person suffering from anæmia. Smears from the ulcerated areas will often reveal the presence of tubercle bacilli, and an examination of the expectoration will generally give a like result. It must be borne in mind that the two diseases may coexist; the ulceration, being originally syphilitic, may take on tuberculous action.

In carcinoma the difficulty of a differential diagnosis is much greater. Here a new growth precedes the stage of ulceration, and it is in this latter condition that the difficulty of a diagnosis so often arises. In carcinoma the disease presents itself more frequently as an ulcerating outgrowth, rather than as a true, deep, excavating ulcer such as is observed in syphilis. The ulcerating outgrowth has a more vascularized appearance and bleeds very easily on manipulation. The surrounding inflammatory area is of a much deeper color than that which is seen in syphilis. The progress of a carcinomatous ulcer is much slower than that of a syphilitic one. Other subsidiary points which are frequently considered in the question of a differential diagnosis, are:

the age of the patient, the presence or absence of enlarged glands, and the existence of pain. But, in the writer's experience, these afford very little support for either view of the case.

Microscopical examination of a portion removed is often doubtful in its results, but recourse should always be had to it, for occasionally it has given satisfactory aid. But the writer has, on the other hand, repeatedly subjected portions thus removed for examination with a very unsatisfactory result. This, however, may be explained by the fact that the portion removed has not been from the more deeply situated tissue. In doubtful cases, recourse to proper antisyphilitic remedies may clear up the difficulty, and yet one must not be too sanguine as to ultimate results, for the iodide of potassium has often the effect of producing absorption of the inflammatory products in cases of carcinoma and thus materially altering the picture presented. One is sometimes confronted with the further difficulty of finding the two diseases (syphilis and carcinoma) coexisting.

Prognosis.—The prognosis to be expressed in any given case of syphilis of the larynx depends upon: 1st, the absence of any other coexisting disease (tuberculosis and carcinoma); 2d, the extent of the existing lesions; and 3d, the faithfulness with which the patient will adhere to treatment and advice. In the secondary lesions recovery usually takes place without leaving any noticeable after-result. In the tertiary stage, when ulceration is present, the progress is usually readily arrested and the function of the larynx interfered with only so far as the destructive process has extended. When cicatrization has occurred very little improvement is to be expected from treatment.

Treatment.—The treatment of syphilis of the larynx is similar to that of syphilis affecting other parts of the body. In the secondary manifestations mercury, exhibited by the process of inunction, furnishes by far the most satisfactory results. It must be admitted that at times it is very difficult to carry out this mode of treatment with any degree of thoroughness; and yet, unless this be done, one can scarcely hope to secure very satisfactory results. The details of this method of treatment will be found in the general article on *Syphilis*.

Locally, alkaline sprays, such as Dobell's and Seiler's, and sedative inhalations (compound tincture benzoin) are indicated, and, after the subsidence of the acute stage, applications of weak solutions (gr. xx.–xxx. to the ounce) of nitrate of silver may be applied to the larynx. In the tertiary manifestations (gummatous and ulcerous infiltration) iodide of potassium in increasing doses is indicated. The writer's method of giving it is in a saturated solution (one ounce of the iodide to one ounce of water), each drop of which approximately represents one grain of the iodide. It is well to begin with small doses, ten drops, to be taken in half a tumblerful of water three times a day *before* meals. It is to be noted that most physicians prescribe the iodide after meals, and this is the reason, the writer thinks, why one frequently hears the complaint that the iodide disagrees with the patient, producing symptoms of indigestion. And so it does, for the iodide of potassium given after meals neutralizes to a very great extent the action of the gastric juice. The writer has repeatedly met with patients who have made such complaints, and, upon their taking the iodide before meals, not only did they find that it agreed with them but they were able to take it in much larger doses. The quantity of the iodide should be slowly increased, and, if we watch its effect upon the ulceration or the gummatous condition, we may find it necessary to increase the dose to gr. l. or lx. three times a day. The chief points in the administration of this drug for syphilitic affections are, that it should be taken before meals and that it should be largely diluted. The acne accompanying the use of the iodide may be moderated by the administration of small doses (♏ i.–iij.) of Fowler's solution after meals.

Locally, cleansing the ulcerated area with alkaline and antiseptic sprays and the subsequent application of a solution of nitrate of silver (gr. xx. or xxx. to the ounce), or the insufflation of iodoform or iodol, will very materially assist in the healing process and moderate the offensiveness of the breath. Vegetations may require the use of the curette, forceps, galvano-cautery, or chromic acid, to hasten their disappearance. Neither general nor local treatment avails when fibroid changes with extensive hypertrophy have already taken place. The local treatment of adhesions and of fibrous bands or membranes, and of stenosis of the larynx, is dealt with in the preceding article, to which the reader is referred.

When syphilis and tuberculosis coexist it is generally agreed that the syphilitic element should first receive treatment. In all forms of syphilis of the larynx smoking and the use of alcohol in any form should be prohibited.

Syphilis of the Trachea and Bronchi.

The trachea and bronchi are less frequently involved in the syphilitic process than are the upper portions of the respiratory tract. It is rare to find these regions involved without existing lesions in the remaining portion of the respiratory tract, for usually the conditions here found are extensions of the process existing above. Mucous patches have occasionally been met with and may be found situated in any portion of the trachea. Gummata, in the writer's experience, are more frequently met with; they are usually single, although occasionally several

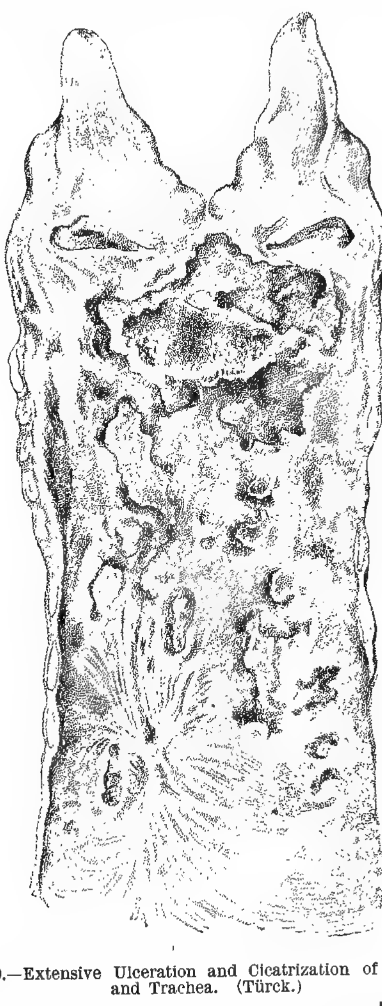

Fig. 3150.—Extensive Ulceration and Cicatrization of the Larynx and Trachea. (Türck.)

are present at the same time. As regards the situation occupied by these lesions, I may say that those which I saw (three cases) were located on the posterior wall of the trachea. They vary in size and to such a degree that in some cases they may produce no symptoms at all, while in others they may give rise to the symptoms of increasing stenosis. In the ulcerative stage the lesions may, as in the case of the gummata, be multiple, but usually they are single and very extensive, as seen in the accompanying figure (Fig. 3150). Cicatrization is also apt to be extensive, the affected areas assuming a great variety of shapes.

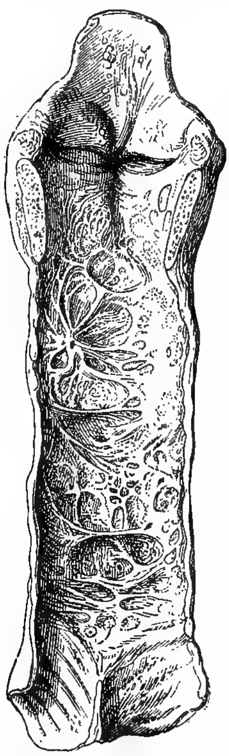

Fig. 3151.—Syphilitic Cicatrices of the Larynx and Trachea. (Orth's "Pathologische Anatomie.")

The *symptoms* depend upon the nature and extent of the lesions present. In some cases they may be insignificant, but in others they are alarming, especially when stenosis exists. The *prognosis* of syphilis in these regions is more unfavorable than when the disease affects the larynx, there being greater danger of hemorrhage from perforation of the ulcer into the aorta or the pulmonary artery. Perforation has also taken place into the mediastinum or into the œsophagus. When stenosis exists as the result of cicatrization the outlook is very grave.

The *treatment* resolves itself into that of syphilis in general. Local treatment cannot be carried out with any degree of certainty. The surgical treatment of stenosis of the trachea is dealt with in the article on that subject.

Congenital Syphilis of the Larynx, Trachea, and Bronchi.

Congenital syphilis of these regions has long been recognized but in an indifferent way, and it remained for John N. Mackenzie to draw the attention of the profession to its more frequent occurrence than was generally admitted, by a most scholarly article which appeared in the *American Journal of the Medical Sciences* in 1880. And, as the writer has seen only seven cases within his own experience, he has largely drawn upon Mackenzie's paper for the full and elaborate information there given of this interesting subject.

"Laryngeal affections in congenital syphilis are the most common and characteristic of its pathological phenomena, and invasion of the larynx may be looked for with the same confidence in the congenital as in the acquired form of the disease."

The larynx may be involved at any age, but the disease more commonly shows itself within the first six months after birth. In the writer's cases the ages were as follows: Two within the first year, three between the ages of four and five years, and two between the ages of six and ten years. As to sex, it is more frequently met with in the female—in the proportion of three to two (Mackenzie). In the writer's cases, four were females and three males. In congenital syphilis of the larynx three distinct forms are to be met with: In the first, the lesions involve the mucous membrane and the submucosa; in the second, the lesions involve the deeper structures, and are characterized by extensive ulceration rapidly involving the cartilaginous framework of the larynx; in the third form, there is a deposit of dense, fibrous tissue leading subsequently to contraction and stenosis.

Symptoms.—In the early manifestations of the disease the subjective symptoms are those of an intense laryngitis, the voice being quite hoarse, and in two of the writer's cases, seen in infancy, nothing more than a very marked hyperæmia of all the laryngeal structures was observed, the examination being carried out under a general anæsthetic. The coexistence of cutaneous syphilis is of frequent occurrence. In the secondary stage the presence of extensive ulceration involving the epiglottis and laryngeal structures leads to the cry of the child being extremely hoarse and more deeply pitched than in the early stages. The cough is harsh and paroxysmal, leading frequently to an attack of vomiting, and deglutition is often difficult. In the third variety the voice is almost aphonic, and, in consequence of the lumen of the larynx and trachea being considerably reduced, there is marked respiratory difficulty, amounting in some cases to orthopnœa, cyanosis, and convulsions. The degree to which stenosis of the trachea may reach in this form is well shown in the accompanying figure taken from a specimen in the Museum of the Medical Faculty of McGill University (Fig. 3152).

Diagnosis.—In the early forms of the disease it may be mistaken for simple laryngitis, but often there are other symptoms of the inherited form to be seen in the skin and mucous membranes of the mouth and throat. In the more advanced form the evidence of the disease may be found in the state of the teeth, the condition of the eyes, and the presence of cicatrices about the angles of the mouth.

Prognosis.—The prognosis of congenital syphilis of these regions is always grave, but less so in the earlier stages, when, if the affection be recognized and treated, favorable results may be looked for. In the later forms of the disease, however, even when its true nature is recognized, the treatment seems to produce less effect than it does in the acquired form.

Treatment.—The best method of treating these forms of infantile syphilis is by the use of the mercurial ointment. A small quantity of this may be applied on the walls of the abdomen, and a small flannel binder also containing a small quantity of the ointment may be applied about the body. One must be careful in using mercurial ointments on the skin of very young infants, as, owing to its being particularly sensitive, the application may do harm. Calomel, gr. $\frac{1}{6}$, three times a day for several weeks; pulv. hydrargyri cum creta, gr. $\frac{1}{4}$–$\frac{1}{2}$, may also be given. General tonic treatment should follow a course of mercury. *Herbert Stanley Birkett.*

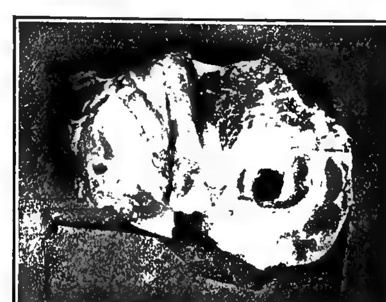

Fig. 3152.—Congenital Syphilis of the Trachea, showing very marked Stenosis. (Pathological Museum, McGill University.)

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LARYNX, DISEASES OF: TUBERCULOSIS.—DEFINITION.—Tuberculosis of the larynx is a disease characterized by an infiltration, into the mucous membrane of the larynx, of newly formed cells among which are to be found tubercle bacilli, and frequently by the breaking down of the tubercle and the formation of ulcers. The disease may involve the perichondrium and cartilage, resulting in caries and necrosis of these structures.

HISTORY.*—Ulcerations on the larynx were first definitely described by Morgagni[1] and subsequently researches were made by Petit,[2] Sauvée,[3] and others. The close relation, however, existing between laryngeal and pulmonary phthisis was not clearly established until 1825, when Louis[4] made public his famous contribution. In this treatise Louis laid special emphasis on the point that "ulcerations of the larynx, and especially those of the trachea and epiglottis, must be considered as lesions of phthisis." The acceptance of so broad a statement as this necessarily led to many errors of diagnosis and much confusion, which, however, were cleared up by the publication, two years later, of the results of the investigations of Trousseau and Belloc,[5] who showed the existence of three kinds of ulcerations in the larynx, viz., those caused by syphilis, tuberculosis, and cancer respectively.

With the settlement of the clinical status of laryngeal phthisis as an ulcerative process belonging to the tuberculous dyscrasia, and entirely distinct from syphilis and other diseases, there sprang up a new topic for dispute, viz., as to the tuberculous or non-tuberculous character of the disease. Louis[4] denied the existence of tubercle in the affection, taking the ground that the ulcerations in the larynx were due to the corroding action of the discharges from the diseased lung passing over its surface. Trousseau and Belloc,[5] on the other hand, believed that there were deposits of true tubercle in the laryngeal membrane which gave rise directly to the ulcerative process, although they acknowledged that their researches had failed to discover them.

The teaching of Louis as to the non-tuberculous character of the disease was followed by that of Andral,[6] Cruveilhier,[7] Rhule,[8] and others. The tuberculous character of the disease was asserted by Barth[9] and Lhéritier,[10] in France, and by Rokitansky,[11] Günsberg,[12] Tobold,[13] and Virchow,[14] in Germany. The latter, in giving the weight of his great name in favor of the tuberculous theory, recommends the larynx for the study of those who "wish to know the true tubercle," and in a later contribution[15] writes: "I am absolutely convinced that laryngeal phthisis is due to tuberculization of the larynx."

The later and very painstaking investigations of Heinza,[16] supplemented by those of Eppinger,[17] have been so thorough and so exhaustive that they have received very general acceptance as settling this vexed question in favor of the view which traces the origin of the disease to a direct deposit of true tubercle.

We thus reach the conclusion that laryngeal and pulmonary phthisis are one and the same disease, and yet the tuberculous process shows marked differences in its manifestations and development in the two regions. This difficulty, however, has been very ingeniously overcome by Virchow,[14] who explains that a superficial deposit of miliary tubercle in a membrane exposed to injury is very liable to break down early and to change into an ulcerative process before the more advanced or caseous changes have had time to set in.

ETIOLOGY.—Laryngeal tuberculosis is usually secondary to pulmonary tuberculosis. The disease is more common in males than in females, the proportion being about 3 to 1. The following table taken from Lake,[18] shows clearly the influence of age as an etiological factor:

Age.	Mackenzie.	Lake.	Total.
1 to 10 years	1	2	3
11 to 20 "	34	29	63
21 to 30 "	194	107	301
31 to 40 "	162	67	229
41 to 50 "	82	44	126
51 and upward	27	10	37

It will be seen that while a few cases occur under ten years of age, and a somewhat greater number between the eleventh and twentieth years, most occur between the ages of twenty-one and thirty; that in the period from thirty-one to forty the disease is very frequent and gradually diminishes in the next decade; while a few cases are seen beyond fifty.

Occupation has a marked influence upon the production of laryngeal tuberculosis. Those whose daily work brings them in contact with a considerable amount of dust which has to be inhaled—such as bakers, stone-cutters, and the like—are very prone to both pulmonary and laryngeal tuberculosis. The sedentary occupations also seem to predispose to involvement of the larynx. As a predisposing factor may be mentioned the fact that any chronic inflammation of the larynx, such as that which frequently accompanies chronic hypertrophic rhinitis or pharyngitis, is far more apt to result in the larynx becoming affected with tuberculosis in those individuals who already have the pulmonary form of this disease than in those whose lungs are healthy. It is probable that the cause of the involvement in these cases is a direct infection of the laryngeal mucous membrane by the sputum laden with tubercle bacilli which is brought up during the course of pulmonary tuberculosis. The thick folds in the mucous membrane often seen in chronic laryngitis, between the arytenoids and on the posterior wall of the larynx below the arytenoids, are favorable spots for the retention of tuberculous sputum. Maceration and softening of the epithelium and superficial ulcers resulting from such maceration are highly probable sources of infection. Any acute inflammation of the larynx occurring in a person having pulmonary tuberculosis is liable to result in superficial erosion of the epithelium, thereby affording a point of ingress for the tubercle bacilli. The ulcerations occurring in the course of syphilis of the larynx in a person afflicted with pulmonary tuberculosis are peculiarly liable to infection with the tubercle bacilli; in which case the so-called mixed infection will occur in the larynx.

Statistics vary considerably as to the frequency with which pulmonary tuberculosis is complicated with laryngeal tuberculosis. Most statistics are the result of observations made in dead-houses and come from the general hospitals in the larger cities of Germany where autopsies are made upon nearly all persons dying in these institutions. Thus Schroetter, in Vienna, found the larynx involved in only six per cent. of the cases, while Heinze, of Leipsic, found laryngeal involvement in fifty-one per cent. of the cases of pulmonary tuberculosis. Lake[18] claims that fifty per cent. of all cases of pulmonary tuberculosis have tuberculous involvement of the larynx. This percentage is somewhat higher than laryngologists generally are willing to admit, the greater number believing that the larynx is involved in only about one-third of the cases of pulmonary tuberculosis.

Much discussion has been going on as to whether the larynx is or is not the seat of a primary tuberculous lesion. It has not infrequently happened to me that the first evidence of the existence of tuberculosis in a patient has been discovered by my examination of the larynx and the finding of typical tuberculous laryngitis. In these cases it usually happens that the contemporaneous examination of the chest reveals pulmonary tuberculosis. In a few cases, however, it has not been possible to detect evidence of pulmonary disease for a period of several weeks following the diagnosis of laryngeal tuberculosis. This must not be taken as furnishing positive evidence that the larynx was the primary site of the infection, for we well

* This historical account is taken unchanged from the article on "Phthisis of the Larynx" in the first edition of this HANDBOOK.

know that it is often impossible for any physical examination of the chest to reveal the very earliest changes that occur in pulmonary tuberculosis. Then, again, the changes in breathing and the breath sounds due to the laryngeal involvement often mask the early physical signs of the pulmonary condition, which probably would have been noted had they not been changed as a result of the laryngeal involvement. However, a few cases of undoubted primary tuberculosis of the larynx have been reported. Thus, Fraenkel[19] reports a case of laryngeal tuberculosis with ulceration and tubercle bacilli in the sputum in which the autopsy revealed tuberculous ulcerations on the arytenoids and vocal cords of the larynx, while the lungs did not show any evidence of tuberculosis. Dehio,[20] Avelus,[21] Germain Sée,[22] Aronson,[23] Moritz Schmidt, Rualt,[24] and Clark[25] have all reported cases of undoubted primary laryngeal tuberculosis.

I think, however, that great caution should be exercised in making a diagnosis of primary laryngeal tuberculosis unless there is—and remains for some little time after the diagnosis is made—an entire absence of evidence of tuberculosis in every other portion of the body.

Tubercle bacilli can gain entrance to, or infect, the laryngeal mucous membrane in one of three ways. 1. Through the lymphatics, and this is probably the most common way and accounts for the greater frequency of the disease upon the side of the larynx corresponding to the lung involved. 2. By deposit of the tubercle bacilli in the submucosa of the larynx as a result of their presence in the blood stream, originating probably in the passage of the blood through the lungs. 3. Infection through slight abrasions of the mucous membrane, more frequently, of course, from the tubercle-laden sputum, in the ulcerative stage of pulmonary tuberculosis, and occasionally from inhalation of dust contaminated with the tubercle bacilli and the deposit of these on the laryngeal mucous membrane.

Pathology.—The pathological changes occurring in the larynx may conveniently be divided into four heads: 1. Anæmia; 2. Hyperæmia; 3. Infiltration; 4. Ulceration.

1. *Anæmia.*—In very many cases the first change to be noticed in the mucous membrane of the larynx is an intense pallor. The vocal cords, ventricular bands, aryepiglottic folds, epiglottis, and as much of the tracheal mucous membrane as may be visible will be noticed to be extremely pale, almost bloodless. It is not uncommon to find over one or the other vocal cord, especially near the vocal process of the cord, a few dilated capillaries, the area adjoining them standing out quite pink in contrast to the rest of the mucous membrane. Such unilateral, localized engorgement of the blood-vessels in a pale mucous membrane in a person who has pulmonary tuberculosis is almost pathognomonic of a beginning tuberculous laryngitis. The pallor is probably due to secondary anæmia, for a quite similar pallor is frequently found in the mucous membrane of the soft palate and posterior pharyngeal walls.

2. *Hyperæmia.*—In a few cases an intense hyperæmia of the entire laryngeal mucous membrane has been observed as antedating the appearance of tubercle. In such cases which have come under my own observation the hyperæmia has resisted all methods of treatment which have been employed, and, when round-cell infiltration has later taken place, ulceration has followed very quickly, and the course of the disease, both pulmonary and laryngeal, has been one of extreme rapidity.

3. *Infiltration.*—The round-cell infiltration, with the formation of giant cells in the infiltrated area, is the commonest form of pathological change met with. The portions of the larynx involved are the posterior commissure of the larynx between the arytenoids, the vocal cords, the aryepiglottic folds, the ventricular bands, and the epiglottis. In the posterior commissure the infiltration produces a corrugated appearance of the membrane, and oftentimes the tissue is so heaped up as to present the appearance of a tumor which may be sufficiently large to hide entirely any view of the posterior portion of the vocal cords. The tumor may be of such size as to encroach markedly upon the lumen of the larynx and be a prominent factor in the dyspnœa from which the patient suffers. The mass is usually pale and somewhat irregular in outline.

Infiltration of the vocal cords may take place anywhere throughout their extent and may be unilateral or bilateral. The affected cord is usually deformed, the even contour of the inner border being replaced by a wavy outline. The infiltrated area in the acute form appears quite red, whereas in the more chronic forms it is pale in color.

The infiltration in the aryepiglottic folds is quite characteristic, and from it alone in many cases a diagnosis of laryngeal tuberculosis can be made. Both aryepiglottic folds are more frequently involved, although one may be involved to a greater extent than the other. The swelling has the characteristic pear shape, the bases of the swellings being situated over the arytenoids and the apices extending outward toward the epiglottis. There is considerable œdema of these folds, which in the stage of infiltration alone has a peculiar pale, translucent appearance in the majority of cases. It is very rarely that one finds this swelling of a bright-red appearance, as is met with in acute inflammation or in syphilitic involvement of the larynx. In a few cases small yellowish nodules can be seen studding the infiltrated area. These are either the result of an accumulation of retained secretion in the mucous glands found in this region, or else they are due to the presence of small miliary tubercles.

Infiltration into the ventricular bands may be accompanied by the same sort of pallor which is found in the aryepiglottic folds, or if ulceration is soon to make its appearance the mucous membrane may be quite red. The ventricular bands are often so swollen as to hide any view of one, or, if bilateral, of both vocal cords. When the mucous membrane of the ventricular bands of the larynx is involved, the swelling accompanying this infiltration may be so marked as to cause the appearance of prolapse of the ventricle with the appearance of two ventricular bands on that side.

The appearance of the epiglottis in the stage of infiltration is also quite characteristic. The swelling that occurs upon the free margin of the epiglottis gives it, when viewed in the mirror, that peculiar broad aspect known as the turban-shaped epiglottis. When the infiltration is great, it is often impossible, on account of the inability to draw the epiglottis forward, to get a view of any part of the larynx, except perhaps the region of the aryepiglottic folds. As in the case of infiltration of the aryepiglottic folds, small grayish-white nodules may sometimes be seen studding the infiltrated area, and these are either obstructed gland ducts or miliary tubercles.

4. *Ulceration.*—Ulceration is usually sooner or later found in nearly all cases of laryngeal tuberculosis. It is only occasionally that one finds, in the tumor-like infiltration that occurs in the interarytenoid commissure in chronic cases of pulmonary and laryngeal tuberculosis, that ulceration does not occur. The ulcers may, therefore, be found in any of the above regions in which we have described infiltration. The ulcerative process is very apt to occur at more than one part of the infiltrated area, and at first may present the appearance of several small superficial ulcers which rapidly break down and coalesce, thus producing one large ulcer, the outline of which is very apt to be irregular; hence the "mouse-nibbled" appearance that is frequently described as characteristic of these ulcers. They are usually superficial and covered with grayish-white exudate in the scrapings from which tubercle bacilli can almost always be found. Very rarely these ulcers undergo healing with loss of more or less tissue from the part they involved. Thus we have seen the greater portion of one vocal cord destroyed by this ulcerative process; the crico-arytenoid articulation may become destroyed, and the arytenoids are often lost, with ankylosis and consequent fixation of the vocal cords. The greater part of the epiglottis may be destroyed by the ulcerative process, which may later be arrested, leaving only a stump of the epiglottis remaining. When the

ulcerative processes—as they occasionally do—involve the perichondrium of the cricoid and thyroid cartilages, necrosis of these cartilages results and abscess in the neck may occur, with the formation of fistulæ leading to the larynx.

Symptoms.—The first symptom that is usually present in connection with laryngeal tuberculosis is hoarseness. Although the hoarseness may be the result of an acute laryngitis that is not tuberculous, yet in every patient with pulmonary tuberculosis, as soon as hoarseness manifests itself, a careful examination of the larynx should be made to determine its cause. The individual may speak clearly for a little while and suddenly become hoarse, and then, after he has uttered two or three words, and has perhaps cleared his throat, the voice may again become perfectly clear. When there is considerable infiltration of the tissue the voice may become aphonic or whispering. The changes in the voice may be due to one or more of the following conditions: 1. Mechanical interference with the action of the vocal cords, as when there is marked infiltration of the interarytenoid commissure and also when there is œdema of the aryepiglottic folds. 2. Infiltration of the vocal cords, causing unevenness in their contour and thereby interfering with their proper approximation during vocalization. 3. Thick, tenacious mucopus brought up from the lungs or derived from the laryngeal ulcers may be temporarily deposited upon the cords, thus interfering with their action; but when the throat is cleared, the removal of these permits of proper vocalization. The sudden alteration in the pitch of the voice that is so frequently noted in patients with tuberculous laryngitis, is most probably caused by the presence of mucus on the vocal cords. 4. The muscles of the larynx may be involved so that they are interfered with in contracting, and thus the proper approximation of the cords is prevented. 5. The recurrent laryngeal nerve on one or the other side may become implicated in the tuberculous process in the thorax and thus produce loss of innervation of the laryngeal muscles; paresis and then paralysis occur, interfering with the proper approximation of the vocal cords. When the right vocal cord is paralyzed it becomes so, most commonly, as the result of a pleurisy at the apex of the right lung, in which the right recurrent laryngeal nerve becomes embedded in the pleuritic exudate. Paralysis of the left vocal cord is more commonly due to intrathoracic pressure of the enlarged bronchial glands which are found at the root of the lung, upon this nerve as it winds around the aorta. 6. In advanced lesions of the lungs the volume of air contained in the thorax may be so much less than normal that, with the weakened condition of the muscular system generally, the blast of expired air is insufficient to cause the vocal cords to vibrate properly, and the voice, as a result, is weak and aphonic.

If the epiglottis or the aryepiglottic folds are involved, a feeling as if there were a lump in the throat, accompanied with difficulty in swallowing, is frequently complained of by the patients. When the disease process is limited to the interior of the larynx dysphagia is seldom complained of. When ulcerations appear—especially when the epiglottis or aryepiglottic folds are involved—dysphagia and odynophagia are very marked, so much so that it is only with difficulty that the patients can be coaxed to take any nourishment. Reflex pain radiating to the ear, root of the tongue, and sides of the pharynx often distresses the patient very markedly.

Other symptoms of which the patients are apt to complain, such as cough, fever, emaciation, night sweats, and profuse expectoration, are those which are found in all cases of pulmonary tuberculosis; they may sometimes be intensified by the laryngeal condition, but are not peculiar to it.

Diagnosis.—The diagnosis of laryngeal tuberculosis is usually readily made. Examination of the larynx and the finding of such conditions as have been described under the heading of pathology, usually suffice to make one positive of the existence of this condition. The four diseases of the larynx which are accompanied by infiltration and ulceration are tuberculosis, syphilis, carcinoma, and lupus. The following table, modified from that arranged by Dr. J. S. Gibb, shows the main differential points between these:

Tuberculosis.	Syphilis.	Carcinoma.	Lupus.
Pain severe on deglutition	Pain usually slight	Pain constant, lancinating	No pain.
Favorite site in the interarytenoid space, and base of arytenoid cartilages.	Attacks any portion of the larynx	Attacks any portion of the larynx	Attacks epiglottis.
Ulcerates slowly	Ulcerates rapidly	Ulcerates more slowly than syphilis.	Ulcerates very slowly.
Usually first appears as small spots or nodules which are rapidly followed by great œdema.	Is rarely seen in stage of induration, the first evidence being a clear-cut, deep ulcer.	First appearance is that of a new growth occupying laryngeal cavity; no clear-cut ulcer.	Nodular mass.
Great œdema of arytenoids	Some induration around ulcer, but usually very little œdema.	The growth fills or encroaches upon the laryngeal cavity.	Little or no œdema.
Ulcers extend laterally but not deeply.	Ulcers extend deeply, often involving cartilage.	Growth extends in all directions, involving all tissue in its course.	Very slow in progress. Ulcers rarely observed.
Surface of ulcer covered with thick muco-purulent secretion and agglutinated mucus.	Surface of ulcer covered with muco-purulent secretion and necrosed tissue.	Surface of growth covered with discharge.	Little or no discharge.
Mucous membrane usually pale	Mucous membrane hyperæmic, injected.	Mucous membrane hyperæmic	Mucous membrane injected.
Laryngeal stenosis rarely occurs	Laryngeal stenosis uncommon until cicatrization occurs.	Laryngeal stenosis common	Slight stenosis.
Health impaired previous to laryngeal involvment.	General health unimpaired	Early in disease no impairment of general health. Later, marked cachexia.	Very little impairment of general health.
Previous or coincident pulmonary trouble common.	Frequently evidence of syphilitic disease in other tissues.	In primary laryngeal carcinoma no other evidences until later in the disease.	Frequently nasal, pharyngeal, and cutaneous manifestations.
Iodides have no influence	Readily improves under iodides	Iodides may at first have slight influence, later none, on the course of the disease.	Iodides have no influence.

Injection of a small amount of tuberculin, 1 to 5 mgm., hypodermically, is advocated by Dr. Trudeau as a means of differentiating laryngeal tuberculosis from other laryngeal infiltrations in cases in which a positive diagnosis cannot be made, especially when pulmonary tuberculosis cannot be certainly demonstrated. The patient's temperature should be taken every four hours for three days previous to the administration of the tuberculin, and again taken at the same intervals after the injection. A rise of temperature of two or three degrees indicates tuberculosis, and it will be noticed that the infiltrated area in the larynx will become hyperæmic and somewhat increased in extent if it is tuberculous.

Prognosis.—The prognosis in laryngeal tuberculosis depends on three things: (1) The character of the tuberculous process existing in the lungs; (2) the form in which the tuberculous involvement of the larynx manifests itself; and (3) whether the patient can put himself in the best hygienic surroundings and under the best and most skilful treatment.

When acute pulmonary tuberculosis is complicated by any form of laryngeal tuberculosis, the prognosis is always grave. These patients, even under the best hygienic conditions, seldom live more than a few weeks. Laryngeal tuberculosis manifesting itself in the late stages of pulmonary tuberculosis is a very grave complication, and, even with the best hygienic surroundings and most skilful treatment, contributes to an early demise.

Let us consider laryngeal tuberculosis developing in a patient who has pulmonary tuberculosis with infiltration and slight softening of a portion of one lung. If such a patient can afford to seek a climate in which the pulmonary process is often arrested, and will consent to do so, then with proper local medication he will have a good chance for a cure of the laryngeal tuberculosis. If, however, he has to remain in a large city and toil at work which undermines his strength, the prognosis is bad. In other words, we feel that the influence of nutrition in a given patient and the arrest of the pulmonary process are of the very first importance in effecting a cure in laryngeal tuberculosis.

In the tumor-like form of laryngeal tuberculosis appearing in the interarytenoid commissure, which often shows little or no tendency to ulceration, and is frequently found in the more slowly developing forms of pulmonary tuberculosis,—that is, the so-called fibroid phthisis,—the prognosis, if the patient can be put under proper hygienic surroundings and treatment, is good.

In the cases of laryngeal tuberculosis that begin with intense redness and are soon followed by considerable infiltration and early ulceration, the prognosis is bad.

Treatment.—The treatment of laryngeal tuberculosis may be considered under three heads: (1) Local; (2) constitutional; (3) hygienic.

In the *local treatment* of laryngeal tuberculosis, in the last few years, considerable reaction has taken place in the direction of the employment of less radical and harsh measures. The application of medicaments to the larynx upon swabs has been dispensed with by many because it is believed that the traumatism caused by the pressure of the swab and the spasm of the parts on being touched do more harm than the application does good. Inhalations and sprays therefore are more frequently used now than ever before.

In the stage in which infiltration alone is present I am in the habit of prescribing as a spray:

℞ Menthol.............................gr. xx.
Ol. eucalyp..........................ʒ ss.
Ol. pini pumilionis.....................♏ xv.
Benzoinol......................q. s. ad ℥ ij.
M. Sig.: Use in oil atomizer.

This may be used in any one of the oil atomizers, the patient being instructed to take a deep inspiration, while the bulb is being compressed, so as to draw the finely divided oil into the larynx.

When the infiltration is excessive, producing dysphagia, as occasionally happens, one of the forms of cutting instruments for the removal of such growths—as, for example, Schroetter's tube forceps or the writer's modification of the same, or Heryng's curette—must be employed.

When ulcerations are present the treatment should consist in cleansing the ulcer with a non-irritating solution, such as the following:

℞ Sod. chlorid..........................gr. xij.
Sod. bicarb..........................gr. xx.
Aquæ........................q. s. ad ℥ iv.
M.

This is best carried out by using a down-tube spray with a compressed air apparatus, the patient's tongue being forcibly pulled out and the degree of air pressure employed being very slight—say five pounds. In this manner the larynx is sprayed so as thoroughly to cleanse it. A powder blower is then filled with

℞ Iodoform..........................gr. ij.
Orthoform..........................gr. i.
Co. stearate of zinc....................gr. i.
M.

and the interior of the larynx is thoroughly dusted with it. In place of the iodoform, when the taste is objectionable, chinosol gr. ij., or paraform gr. ij., may be used. In fact it is sometimes best to vary these three powders in order that the healing action of any one of them may not be lessened by too continuous use. A nurse or some member of the family can be taught to do this, as in some cases it is often necessary to apply it twice daily, to afford relief.

When much pain is associated with the laryngeal ulcers it is well to add to the above powder gr. $\frac{1}{4}$ of cocaine and gr. $\frac{1}{8}$ of morphine. Intralaryngeal injections with a specially constructed syringe are employed by some in the ulcerative stage. Creosote and guaiacol are used for this purpose, ♏ v. of creosote in ♏ xv. of olive oil or albolene being injected into the larynx once, twice, or three times daily. The spasm produced is considerable, and it is well to begin with a smaller amount and gradually to increase the quantity of the injection. Scheppegrell[26] advocates the use of electrolysis in the treatment of laryngeal tuberculosis and reports some good results. The submucous injections of carbolic acid, creosote, or guaiacol, which were in favor a few years ago, have practically been abandoned on account of the severe reaction, with intense œdema of the glottis, that followed their use.

If the epiglottis is enormously swollen and ulcerated so as markedly to interfere with deglutition, beneficial results follow its excision with cutting forceps. This is not done with the idea of curing the tuberculous process, but simply to remove a cause of great distress to the patient and to allow him to take food.

Lactic acid has been and still is employed with beneficial results in the treatment of laryngeal tuberculosis. It is usually advisable to begin with a twenty-five-per-cent. solution of lactic acid and gradually to increase the strength until the pure acid can be tolerated. The application should be made every day on a cotton-wound applicator.

The *constitutional treatment* of the patient should be the same as that for tuberculosis in general.

Hygienic Treatment.—The feeding of these patients in the ulcerative stage, and especially when the epiglottis and aryepiglottic folds are ulcerated, demands considerable attention on the part of the physician. Soft and semi-solid materials seem to be more easily swallowed than either solids or liquids. Scraped beef, either raw or partially cooked, can usually be swallowed with as little difficulty as any form of nourishment and is very nutritious. Custards, the whole raw egg, and oysters are also substances taken with as little discomfort as any. Mark Hovell has suggested a plan by which deglutition in these cases can sometimes be made very comfortable; namely, by having a nurse stand behind the patient with the hand resting on the side of the neck and the fingers inserted on either side of and just above the thyroid cartilages and making firm pressure on the sides of the neck during each act of swallowing. The object of this is to steady the larynx and prevent the compression of the aryepiglottic folds which occurs normally with each act of deglutition. Another method of taking nourishment which seems to act well is this: Let the patient lie, face down, on a couch, the head hanging over the end, and suck up liquid food through a tube.

As a usual thing patients suffering from laryngeal tuberculosis do best in a climate where the temperature is moderate, the air dry but not dusty, and the altitude not too great. Parts of Arizona, New Mexico, southwest Montana, and the Redlands district of California are, on the whole, the parts in this country in which the greatest number of my own cases have been most benefited. I know, however, that it is very difficult to pick out any one locality for a patient with laryngeal tuberculosis and advise him to go there and stay until he is cured. Local-

ities favorable to one patient are not so to another, and it is therefore best to tell the patient frankly to go to a place, and, if he grows worse instead of improving, to go to another, in the hope of finally getting relief.

Cornelius G. Coakley.

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LARYNX, PHYSIOLOGY OF THE.—I. The larynx is that portion of the respiratory tract which is situated in the median line of the neck between the trachea and the pharynx. It may be regarded merely as a prolongation upward of the trachea, with such modifications of structure as are required for the performance of its various specialized functions. A comparative study of the larynges of animals indicates that the extent of the modifications of structure is proportional to the variety of the specialized functions. Following this law, the structure of the human larynx differs very considerably from that of the trachea, and its mechanism is interesting and complex (Figs. 3153, 3154, and 3155). The framework of the trachea is composed of incomplete cartilaginous rings, bearing a close resemblance to one another, and bound together by fibro-muscular tissue, and while the cartilages of the larynx are for the most part irregular in shape, a scheme somewhat similar to that of the trachea is carried into its structure.

The cricoid, the first cartilage above the trachea, differs from all the others in that it is complete throughout its entire circumference, and it thus serves as a firm base for the superstructure of the larynx. The thyroid, like the cartilages of the trachea, is open posteriorly, thus giving room for the two arytenoids which articulate with the elevated posterior portion of the cricoid. The hyoid bone, which is closely related to the larynx, is also open posteriorly to make room for the anterior portion of the pharynx. The other cartilages of the larynx are the cornicula laryngis, the cuneiform cartilages, and the epiglottis. These nine cartilages form the framework of the larynx, and they are so jointed and connected by ligaments as to be freely movable when acted upon by their respective muscles. The object of this motion is threefold: (1) to control the breath, (2) to furnish the bands the vibrations of which cause the sound of which

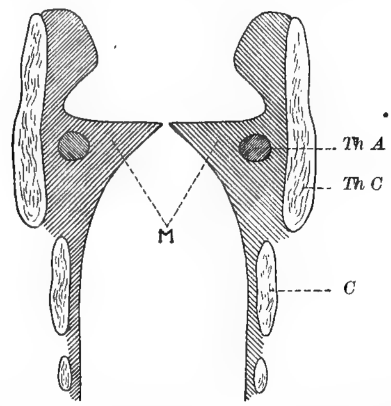

FIG. 3156.—*Th A*, Thyro-arytenoid muscle; *Th C*, thyroid cartilage; *C*, cricoid cartilage; *M*, vocal shelves.

voice is made, and (3) to assist in voice production. The three highly specialized functions of the larynx, therefore, may be described under the following heads: (1) Respiration; (2) Phonation; (3) Articulation.

Respiration.—The respiratory function of the larynx is an important one and it includes more than would appear at first thought. Air could be made to pass to and from the lungs without the intervention of this complicated structure, therefore the mere act of breathing may be regarded as purely incidental to the larynx. It was necessary to place somewhere in the respiratory tract a structure that not only would furnish a free passageway for the breath, but would also, at the same time, serve other important purposes. Of these purposes phonation, to be described later, is the most important, but this requires some kind of temporary obstruction in the air channel, and this is provided by the two muscular bands with their membranous covering, that run from the thyroid to the arytenoid cartilages. Moreover, these bands must obstruct respiration as little as possible and only at those times when the obstruction is necessary for the phonatory act. Provision is therefore made for their removal from the lumen of the larynx when not required for this purpose, and this is accomplished by the contraction of the posterior crico-arytenoid or so-called respiratory muscles. These abductor muscles are supplied by the external branch of the superior laryngeal nerve, and so important are their functions in maintaining the patency of the larynx for respiratory purposes, contracting as they do for every act of inspiration (about eighteen times a minute), that they seem to be endowed with greater strength and are less susceptible to disease than the other muscles of the larynx. Life itself depends upon their health and tone (Figs. 3153, 3154, and 3155). But the larynx has another important function that should be described under this head, and that is the closure of its upper portion during the vigorous muscular acts which are performed by the hands and arms, and also during the acts of defecation, coughing, laughing, etc.

This strong closure of the upper portion of the larynx

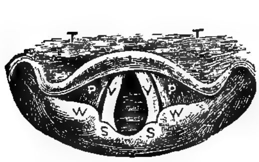

FIG. 3153.—Showing the Position of the Vocal Bands during Passive Inhalation.

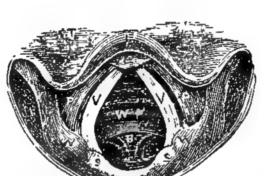

FIG. 3154.—Showing the Position of Vocal Bands during Forced Inhalation.

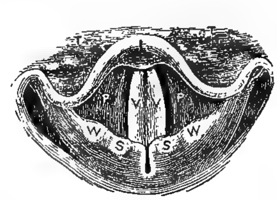

FIG. 3155.—Showing Position of Vocal Bands during Phonation.

FIG. 3153, 3154, AND 3155.—*T*, Tongue; *L*, epiglottis; *P*, *P*, ventricular bands; *W*, *W*, cartilages of Wrisberg; *S*, *S*, cartilages of Santorini; *V*, *V*, vocal bands; *W*, *P*, wind pipe or trachea; *B*, bifurcation of the trachea. (From Lennox Browne and E. Selenke.)

takes place above the vocal bands, and not so much in the glottis as has been supposed. The glottis, it may be remarked, is merely the aperture formed by the vocal bands, the vocal processes, and a portion of the transverse arytenoid muscle (Fig. 3153). The vocal bands are too slender and delicate to endure the strain that would be put upon them by this action, and their structure, shape, and position, when the glottis is closed, render them incapable of resisting much pressure of the breath from below. They are not in reality bands at all in their shape and structure, but if a cross section of them were made (Fig. 3156), they would be found to be somewhat wedge-shaped with the head of the wedge looking upward and the apex downward; their inner edges contribute, during tone production, to the formation of the vibrating portion of the glottis, and their inner surfaces gradually taper downward along either side of the larynx. Better names for them have been suggested, namely, cushions or shelves, and the latter is the one to be preferred because it more accurately describes their shape and functions. It will be observed that when the glottis is closed the gradual tapering of the vocal shelves downward makes the lower portion of the larynx somewhat cone shaped with the apex pointing upward, and that this approach to the glottis adapts it not for checking but rather for favoring the egress of air (see Fig. 3153). When the breath is forcibly held for purposes mentioned above, the true glottis is not closed at all, but the pseudo-glottis is closed by the approximation of the ventricular bands, and the ventricles, the shape of which is so well adapted to this purpose, become inflated and unite to form a more or less perfect valve capable of resisting great pressure with a minimum amount of effort (see Fig. 3156). The upper surface of the closed glottis to a lesser degree acts like a valve in checking the ingress of air. This function, however, is not so important, for the amount of air taken into the lungs is controlled largely by the great respiratory muscles of the thorax.

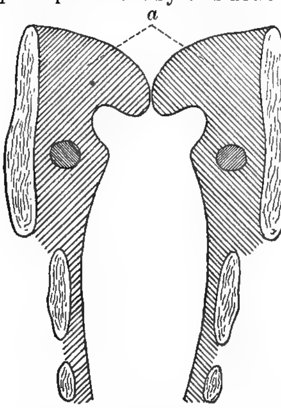

FIG. 3157.—Shows the Valvular Action of the Ventricular Bands. *a*, Ventricular bands.

In addition to this valvular action the upper portion of the larynx closes at times in much the same way as do the sphincters in other parts of the body. It was formerly supposed that the epiglottis, serving as a lid to the larynx, was the only means of preventing the food from entering this cavity during deglutition, but, in refutation of this theory, it was found that the entire removal of the epiglottis, either by operative procedure or by disease, in no respect interferes with deglutition. It appears, therefore, that nature has not entrusted to the epiglottis alone the important function of guarding the gateway to the lungs against the intrusion of foreign substances, but, in addition to and immediately preceding the falling of the epiglottis over the larynx during deglutition, there is a complete closure of the entire upper part of the larynx. This is effected by the approximation of the ventricular bands, the upper part of the arytenoid cartilages, the aryepiglottic folds, and the lower portion, or so-called cushion, of the epiglottis. The muscles causing this closure of the upper portion of the larynx have been called the sphincters of the larynx. They are the thyro-aryepiglotticus, the thyro-arytenoideus externus, and the arytenoideus posticus.

In the act of deglutition the sphincter muscles contract, and over the closed gateway of the larynx the epiglottis falls of its own weight, or rather as a result of the relaxation of the hyo-epiglottic ligament, incident upon the elevation of the larynx. The theory formerly held, that the epiglottis is drawn over the larynx by muscular action, is rendered improbable by the fact that the muscular fibres running from the epiglottis to the hyoid bone, in the human subject, are very small and but slightly developed.

Phonation.—The chief purpose of the larynx and the one to which it is especially adapted is phonation, but this function is so closely related to the action of certain other organs, notably those of respiration and articulation, that it will be necessary to take these into account also, at least to some extent.

Voice, as I have defined it elsewhere, is a moving column of breath, set in vibration by its own impact upon the vocal shelves and re-enforced by its diffusion through the various resonant chambers into the surrounding atmosphere, and therefore it follows that phonation is the process by which the column of breath is formed, set in vibration, and diffused, and a description of this process must include the necessary respiratory movements, and at least a reference to the resonant chambers, as well as a description of the action of the larynx itself.

The respiratory movements of phonation are different from those of ordinary breathing. The one is active, and the other is passive. The breathing of phonation supplies the system with oxygen, and carries off the effete products, in the same manner as does ordinary breathing, but it does this only incidentally, its special function being to cause impaction of air upon the vocal shelves, which impaction causes the necessary vibrations. Moreover, the character of this impaction of the column of breath upon the vocal shelves is an important factor in the regulation of their vibrations. It has been shown by actual demonstration that the rapidity of the vibratory excursions of the vocal shelves is increased and the pitch of the voice heightened by an increase in the rate of motion of the column of breath. This is true, in part at least, because the increase in the rate of motion is attended by an increase of expiratory effort, and a corresponding increase of pressure within the column of breath; the tracheal tube being somewhat elastic, this pressure tends to enlarge the column of breath in the trachea, and as this is forced through the smaller opening of the cricoid cartilage it carries its anterior portion upward toward the thyroid, and its posterior portion downward, thus increasing the distance between the anterior and posterior attachments, and becoming a direct longitudinal tensor of the vocal shelves. On the other hand, if this tendency of the column of breath to render the vocal shelves tense during its rapid and forcible movement is resisted by the contraction of the internal thyro-arytenoid muscles, the result will be a wider vibratory excursion of the vocal shelves and a greater intensity or loudness of voice. In this way the column of breath becomes an important factor in regulating both the pitch and the intensity of voice.

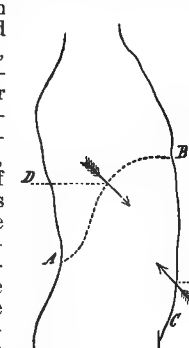

FIG. 3158.—Diagram showing the Opposing action of the Diaphragm and Abdominal Muscles. *A-B*, Diaphragm; *B C*, abdominal muscles; *D*, direction in which the diaphragm acts; *E*, direction in which the abdominal muscles act.

The respiratory movements of phonation, therefore, are definite and active. The base of the column of breath rests upon the diaphragm, and it is surrounded laterally by the walls of the thorax with their enveloping ligaments and muscles. The muscles may be divided into two sets, those which elevate the ribs and those which depress them, the former tending to enlarge the thoracic cavity, and the latter to diminish its capacity. It will be observed that the depressor muscles exert a force which is directly opposed to the action of the levator muscles, and

it is by means of these two opposing forces that the column of breath may be controlled with the necessary accuracy, and that the requisite tension may be given to the drum-like walls of the thorax for the purpose of giving resonance to the voice (Fig. 3158). The column of breath is, therefore, compressed and its rate of motion through the glottis regulated with great precision.

The tracheal, pharyngeal, oral, and nasal cavities are also resonators, and serve to re-enforce the tones produced by the vibration of the vocal shelves.

The framework of the larynx, as already mentioned, is composed of irregularly shaped cartilages articulating at the several points of contact by means of freely movable joints. The muscles having their attachments only to these cartilages, and whose function it is to assist in the regulation of their relative positions, are called intrinsic muscles; those running from the cartilages to various points without the larynx are called extrinsic muscles. The extrinsic laryngeal muscles, like the thoracic muscles, may be divided into two sets, according as they elevate or depress the larynx. The levator muscles are the palatopharyngei, the stylopharyngei, digastric, stylohyoid, geniohyoid, and the hyoglossi. The depressor muscles are the omohyoid, sternohyoid, and sternothyroid. The function of the extrinsic muscles is (1) to determine the position of the larynx in its relation to the adjacent structures, and (2) to determine the position of certain important parts of the larynx in their relation to other parts. The position of the larynx in its relation to adjacent structures varies with the variation in the quality and pitch of the voice, and the importance of a correct position cannot be overestimated. When both the levator and depressor muscles are brought into action, the larynx becomes fixed, and an additional result of these two forces (as will be observed in Fig. 3155) is to draw the larynx backward against the spine. If these two sets of muscles are strongly contracted, the posterior surface of the plate of the cricoid cartilage will be fixed against the anterior surface of the fifth cervical vertebra, and thus vocal resonance may be transmitted through the spinal column to all parts of the body.

Moreover, with the cricoid cartilage in contact with the fifth cervical vertebra, it is evident that if the force of the contraction of the depressor muscles is greater than that of the levator, the result will be a forward tilting of the thyroid upon the cricoid cartilage and a stretching of the vocal shelves. In this way it is quite possible that the extrinsic muscles of the larynx may assist the intrinsic muscles in rendering the vocal shelves tense, at least during the production of tones of unusually high pitch. Opinions differ, however, with reference to this important point, some claiming that the extrinsic muscles are the sole cord stretchers of voice production, others thinking that this function comes entirely within the province of the intrinsic muscles. While this is one of the many questions with reference to the physiology of the voice that are difficult of demonstration, it is quite probable that there may be some truth in both theories and that unusual results in voice production may be attained by a judicious combination of both the extrinsic and the intrinsic muscles in the control of the vocal shelves. The function of the larynx in phonation is to furnish and control the shelves, the vibration of which is the first cause of the sound of which voice is made. These shelves are merely reduplications or folds of the lining membrane of the larynx reflected over the thyro-arytenoid or so-called vocal muscles, the lining membrane of that portion of the shelves which forms the rima glottidis having been transformed, by the exercise of its function, into white fibrous tissue. The various changes in the laryngeal tones of the voice depend upon certain changes in the physical condition of the vocal shelves. The laws governing the vibrations of the vocal shelves are somewhat similar to those governing the vibrations of strings, the three physical changes in them which govern the pitch of the tone being changes in length, weight, and tension. The length and weight of the vocal shelves vary somewhat in different larynges. Those in the larynx of the male, for instance, are longer and heavier than those in the larynx of the female, and the pitch is correspondingly lower. The length of the vibratory portion of the shelves, however, may be changed in each larynx by certain changes in the action of its muscles. This phenomenon may be observed by means of the laryngoscope. When a tone of high pitch is produced, the vocal processes of the arytenoid cartilages appear to meet in the middle line, and the posterior edges of the glottis are held in apposition. The same conditions seem to obtain also with reference to the anterior edges (although in many cases, especially during the emission of low tones, they are partially hidden from view), and thus the vibrations may be limited to scarcely more than the middle third of the glottis (Figs. 3153, 3154 and 3155). The shortening of the glottis posteriorly is brought about by a vigorous contraction of the arytenoid and the lateral crico-arytenoid muscles, causing the vocal processes to come into close apposition and possibly to overlap slightly. At the same time the thyroid tilting muscles, the crico-thyroid and the sterno-thyroid, serve to stretch further the vocal shelves; and the latter muscles when the levator laryngei muscles are in action serve also to compress the alæ of the thyroid cartilage, which compression would naturally bring into closer apposition, not only the posterior but also the anterior edges of the glottis. Moreover, it has been shown by Willis that the approximation of the anterior portion of the cricoid cartilage to the thyroid, which is made evident by placing the finger in this region during the emission of a high tone, has a tendency to push the tapering portions of the vocal shelves upward, and to bring into close contact the anterior edges of the glottis. This theory of the regulation of the glottis by forced muscular action during the production of the higher notes of the falsetto voice is demonstrated not only by the laryngoscope, but also by the conscious increase of the muscular effort required for the production of these tones. The mechanism that shortens the vibratory portions of the shelves, at the same time diminishes the width of their vibrating surfaces and increases their tension. As the internal thyro-arytenoid or vocal muscles contract more and more when their attachments are fixed both anteriorly and posteriorly, as above described, the result is a lateral diminution of the vibrating portions of the vocal shelves. When these vocal muscles are contracted to their utmost, only the very thin edges of the shelves are available for vibration. The internal thyro-arytenoid muscles throw out numerous small muscular fibres into the bodies of the shelves, the function of which is to regulate the extent of the lateral vibratory surfaces of the shelves, and probably also to assist in regulating the longitudinal vibratory surfaces.

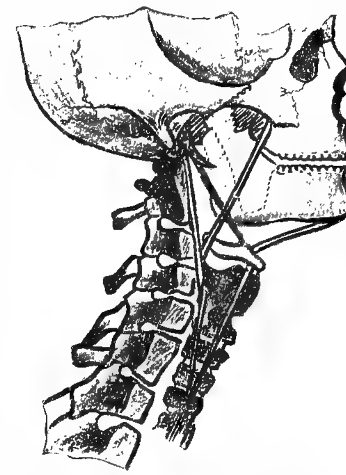

FIG. 3159.—Diagram Showing the Direction in which the Levator and Depressor extrinsic Muscles Act in Holding the Larynx Against the Spine. (From Howard.)

Articulation.—Thus far we have considered the larynx in its relation to tone production. It must be borne in mind that the tone produced by the laryngeal mechanism above described differs from what we hear as the human voice, but this difference is not apparent because it is impossible for the human ear to differentiate the two. If

we could make a section of the larynx containing the vocal shelves as they actually exist, and if by some mechanical measures we could reproduce their actual movements of adduction during tone production, and also at the same time set them into vibration by artificial means, we should then be able to get the primary tonal element of the voice. The vocal shelves hold the same relation to the organs of voice that the strings of a violin hold to the instrument itself. The tones that we hear from the violin are the result not alone of the vibrations of the strings, but of the effect that these vibrations make upon the whole instrument, and so the human voice is the result of vibrations originating at the vocal shelves and modified not only by the larynx itself, but, to some extent at least, by the entire organism. The human voice, therefore, is the result of various complex conditions. People differ, as do violins, both in their composition and in their structure, and as the tones of violins differ, so for the same reason, and to a greater extent, do voices differ one from the other. The simplest tone of the voice reaches the ear as one of the so-called vowel sounds, or as some modification of them. The vowel sounds, therefore, are the purely vocal elements of speech and song. The tone originating in the glottis immediately begins to take on the quality of one of the six physiological vowel sounds, or some combination of them, according to the adjustment of those portions of the respiratory tract which are situated above the glottis. Concerning the mechanism of the production of the vowel sounds there have been numerous theories. It has been generally conceded that the vowel sounds are the results of various combinations of the laryngeal with certain other so-called resonance tones. Helmholtz claimed that the vocal apparatus resembles the pipe organ, the vocal shelves corresponding to the reeds, and the pharyngeal and oral cavities to the pipes; and that, as the reeds of the organ vibrate in wholes for the fundamental tone, and halves, thirds, etc., for the harmonics (overtones), each of the various pipes of the organ selecting the particular harmonic to which its vibratory calibre corresponds, and thus determining the characteristic note of the organ, so the vocal shelves vibrate in wholes for the fundamental tone, in halves, thirds, etc., for the harmonics, and the pharyngeal and oral cavities, being flexible and capable of many variations in shape and size, adjust themselves to correspond to the particular overtone the combination of which with the fundamental tone is characteristic of the vowel sound to be produced.

Up to the present time this has been the theory accepted by the majority of writers and teachers of the subject, but there appear to be decided objections to it, and it does not accord with more recent investigations. Notwithstanding the great flexibility of the laryngeal, pharyngeal, and oral cavities it is probably impossible for them to be adjusted in size and shape to meet the requirements of Helmholtz's harmonic or overtone theory.

Antedating the theory of Helmholtz, and opposing it in some respects, is the theory of Willis. He claims that the resonance tones are independent of the laryngeal tones in respect to pitch. This theory was strengthened by the later experiments of Hermann and others, and it seems about to be verified by extensive investigations now being carried on by Prof. E. W. Scripture, of Yale University.

These investigations are being made with care and accuracy and they cannot fail to be of great scientific value. By means of complicated machinery, enlarged tracings of the curves of speech are taken from gramophone plates, and the character of the vowel sounds is computed by accurate measurements of these tracings. The result will probably change some of the hitherto accepted views concerning the elements of speech and clear up disputed points with reference to voice production. The tracings appear to show that the glottic tone is the result not of actual vibrations of the vocal shelves, but of a succession of respiratory puffs through the glottic chink, and that the resonance tones are the result of free, in contradistinction to forced, vibrations in the cavities above and below the glottis; or, in other words, that the resonance tones are the result of vibrations set up in these cavities by a more or less irregular succession of blows from the vocal shelves.

These investigations also show that the resonance tones are composed of a series of tones that may have a different pitch the one from the other, and that the pitch of the resonance tones does not necessarily change with that of the glottic tone, and therefore that the resonance tones cannot be overtones of the glottic tone, as is commonly supposed. They show, also, that the vowel sounds as they appear in good speech are of almost constantly varying pitch.

This analytical method of studying the curves of speech is only in its infancy, but it is so distinctly scientific in its nature as to warrant this brief description of it, and the interesting results thus far obtained. Whatever may be the truth with reference to these disputed points, we know that the vowel sounds are the result of the proper blending of the glottic with the resonance tones. The principal resonance chambers are the tracheal, upper laryngeal, pharyngeal, oral, and nasal cavities. With the exception of the tracheal and nasal cavities these resonance chambers are flexible and capable of numerous changes not only in their size and shape, but also in the muscular rigidity of their walls, and together they form what have been called the moulds of speech, each vowel sound having its individual resonance mould, which varies more or less continuously in respect both to its shape and its size and to the rigidity of its walls.

Vowels.—It is the manipulation of the mould that determines the character of each vowel sound and that distinguishes one vowel sound from another. The resonance mould may be shortened more than an inch, by the elevation of the larynx and the retraction of the lips. Several of its diameters may also be shortened by the contraction of the lateral walls of the larynx and pharynx, and by the various movements of the epiglottis, velum palati, tongue, lower jaw, and lips. Some of these parts have points of actual contact, thus dividing the mould into several smaller and more or less well-defined compartments with or without communicating passageways. Each compartment has its individual vibrations, and it is the various admixtures of the resultant tones combined with the glottic tone that produce the characteristic elements of speech.

For the sound of *EE* in feet, the mould is shortened by the elevation of the larynx and the retraction of the lips, and it is flattened and narrowed in the linguo-palatal region by the elevation of the tongue and its contact with the lateral molar teeth. Its diameters are also shortened in the region of the ventricular bands and the aryepiglottic folds.

The sound of *A* in ate, requires a somewhat longer mould and a larger labial and linguo-palatal aperture for the beginning of the sound, and for the ending of the sound it approximates the mould for the sound of *E*.

The sound of *Ah*, or *A*, in father, requires a still longer mould and a wider aperture in the labial and linguo-palatal regions.

The sound of *Aw*, as in awe, requires a still longer mould.

In the sound of *O* in old, the long diameter of the mould is considerably increased by lowering the larynx and protruding the lips. The linguo-palatal, pharyngeal, and laryngeal diameters are also considerably increased.

In the sound of *OO* in boot, the lips are somewhat farther protruded and the labial aperture diminished in size.

It will be observed that for the *six* physiological vowel sounds, named in their order as above, the resonance mould grows progressively longer beginning with *EE* as its shortest and ending with *OO* as its longest diameters.

It must be apparent that the above is merely a brief outline of some of the important adjustments of the vowel moulds, and that a precise description of them, for

even a single vowel, would be impossible, because they differ not only in different individuals, but in the same individual during different intellectual and emotional states of mind.

PHYSIOLOGICAL ALPHABET.

Consonants.

	Voiceless oral.	Voiced oral.	Voiced nasal.	
Labials............	P Wh	B W	M	Paul Brown made white wax.
Labio-dentals......	F	V	....	Full voice.
Linguo-dentals....	Th′	Th″	....	Think thou.
Anterior linguo-palatals.	S Sh T	Z Zh D L R	.... N	Some zealous sheep leisurely took down nine large rails.
Posterior linguo-palatals.	K H	G Y	Ng	Can girls bring home yeast?

Vowels.						Coalescents.					
ā	ā	le	ō	ō	ld	a͞r	f	a͞r e	o͞r	f	o͞r e
ă	ă	t	ŏ	ŏ	n	ȧr	f	ȧr	ŏr	f	ŏr
ä	ä	lms	o͞o	o͞o	ze	e͞r	h	e͞r e	o͞or	p	o͞or
a̤	a̤	ll	o͝o	l	o͝o k	ĕr	h	ĕr	ŭr	p	ŭr r
ȧ	ȧ	sk	ĭ	ĭ	t						
ē	ē	ve	ŭ	ŭ	p						
ĕ	ĕ	lk									

Consonants.—There are twenty-three so-called consonant sounds in the English language, and they may be classified, as in the accompanying table, first, according to the particular parts of the resonance mould actively employed in their production (Fig. 3160), and secondly, according to the character of the sounds (see table). It has been observed that the sounds of the five consonants, *P, B, M, Wh,* and *W,* are made by the lips, and, therefore, they have been classified as labials, and that the sounds of *B, W,* and *M* are voiced sounds while those of *P* and *Wh* are voiceless or merely breath sounds. The sounds of *F* and *V* are made with the lower lip and upper teeth and are named labiodentals, the first one being a voiceless, and the second a voiced sound. The sound of *Th,* as in think, and *Th,* as in thou, are made with the tip of the tongue and the upper teeth, and are called linguo-dentals, the first one being voiceless, and the second voiced.

The sounds of *S, Z, Sh, Zh, T, D, N, L,* and *R* are made by the tongue and the anterior portion of the hard palate, and are called anterior linguo-palatals, the *S, Sh,* and *T* being voiceless, and the *Z, Zh, D, N, L,* and *R* being voiced.

The sounds of *K, G, Ng, H,* and *Y* are made by the dorsum of the tongue and the velum palati, and are called posterior linguo-palatals, the *K* and *H* being voiceless, and the *G, Ng,* and *Y* being voiced. In considering the elements of speech it must be borne in mind that the names of the letters of the alphabet do not always indicate the sounds of the letters. For instance, the letter *B* is composed of two elementary sounds, *B* and *E; G* is composed of three elementary sounds,—*D, Zh,* and *E;* and the letter *W* is composed of six elementary sounds,—*Dŭblyo͞o.* Hence it has been found necessary to construct an alphabet of sounds. This was done in 1827 by Dr. Neil Arnott, and his alphabet was modified, during the last decade, by Dr. John Wyllie, of Edinburgh, who gave it the name of physiological alphabet. It is reproduced here with some important additions and alterations. This revised physiological alphabet contains forty-four sounds, and it will be found useful as a standard for comparison in cases of marked defective speech.

Registers of the Voice.—The singing voice has a certain range of pitch that seems to be adapted to a fixed adjustment of the larynx, and in order to increase the range of pitch it is necessary to make a somewhat different adjustment. These changes are accomplished chiefly by the action of the extrinsic muscles, and in going from one adjustment to another it has seemed to be necessary to make a slight break in the voice. This fact has given rise to the so-called upper, lower, and middle registers of the voice, each register having its own particular adjustment of the larynx, and being separated by a more or less marked interruption of the tone, consequent upon the readjustment of the laryngeal mechanism. One great test of the excellence of a vocal method seems to be its power to enable the singer to make the readjustments for

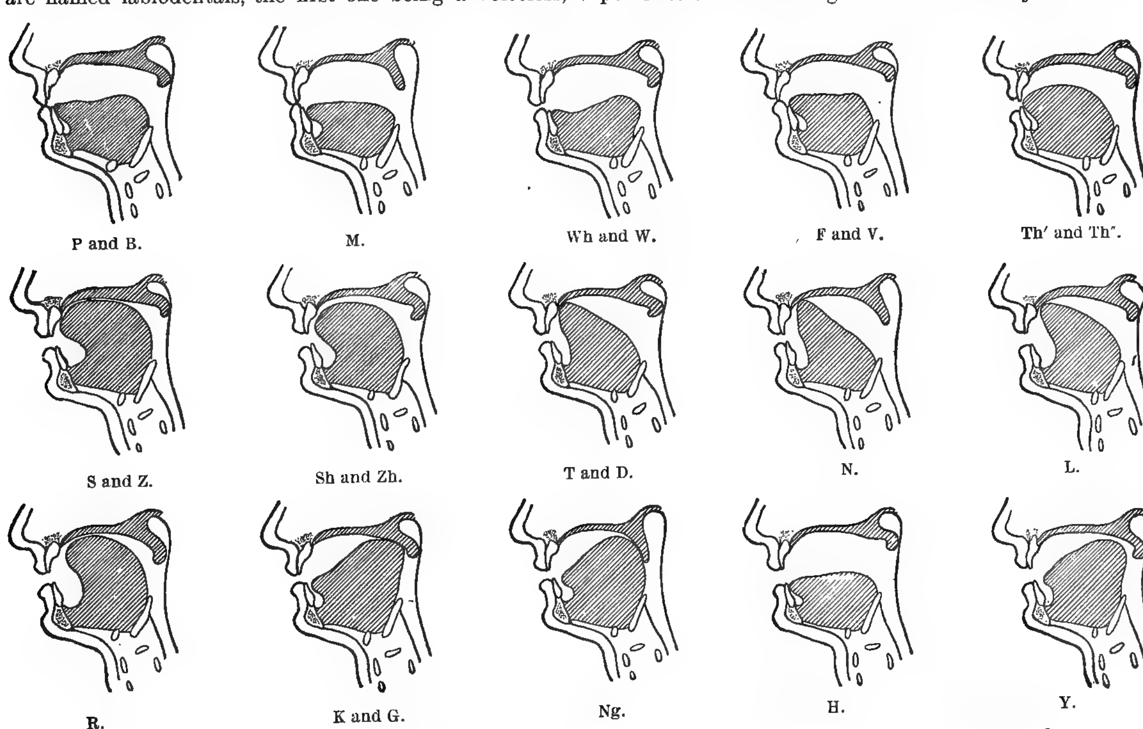

FIG. 3160.—Showing Approximately the Position of the Organs in the Articulation of the English Consonant Sounds.

the different registers with the least possible interruption. If these interruptions or breaks, as they are named, could be eliminated entirely there would be no necessity for the use of the term registers, and this is the position taken by many of the best vocalists and physiologists. It seems entirely within the bounds of reason to suppose that, in the thoroughly trained larynx, the various adjustments of its parts, complicated though they may be, would be accomplished with sufficient smoothness to enable the singer to go from the lowest to the highest pitch with no appreciable break, and that there would therefore be but one vocal register.

The Falsetto Voice.—The thin upper tones of the voice, containing no appreciable resonance from the chest or other large resonance chambers, have been named the falsetto or false voice, in contradistinction to the well-rounded voice resulting from a combination of the laryngeal with all the various resonance tones. The name for this quality of voice is unfortunate, because it has its place both in singing and in speaking, and it differs from the so-called true voice only in the fact that it contains fewer of the resonance tones.

Whispering.—Another quality of voice that must be considered is that of whispering. It is also the result of a combination of laryngeal with resonance vibrations. But the laryngeal tones arise from a free efflux of breath through a comparatively open glottis, and it is quite probable that the ventricular bands also take some part in this fricative sound. The laryngeal vibrations, however, are not of such a nature as to set up additional vibrations in all the resonance chambers. The whispering voice, therefore, is the result of fricative laryngeal vibrations re-enforced by imperfect resonance vibrations.

Defective Speech.—In the majority of cases the immediate cause of defective speech is a faulty construction of the moulds of speech. The remote causes are often more difficult to determine. In their origin they are either central or peripheral, and cases of long standing are both central and peripheral. A cleft palate, for instance, always results in defective speech, and the primary cause is peripheral, but the effort to adapt the faulty organs to the requirements of speech develops a defective action in the motor and auditory centres of the brain which marks the case as coming under the head of both a central and a peripheral affection. The central affection, of course, is purely functional, but it is often exceedingly difficult to eradicate. The patient must be taught to make correct moulds, and it has been found that, when the peripheral organs are intact, a frequent repetition of this process, continued for a sufficiently long time, will correct the faulty cerebral action and improve the habits of speech.

Stammering.—A somewhat less frequent, though more distressing, affection of speech is stammering. Its primary cause may also exist in the peripheral organs, but it is more often of cerebral origin. So complicated are the nervous processes of speech that the only wonder is that the disorder is not more common. The motor processes of normal speech are for the most part automatic, and a slight weakening, for any reason whatever, of a single muscle or nerve, even for an instant, may completely destroy for the time being the automatic action. This leads to a confusion of mind more or less pronounced, which in turn makes extremely possible a speedy repetition of the faulty action, the consciousness of the utter lack of power to control the mechanisms of speech soon follows, and thus the stammering habit becomes fixed. No two cases of stammering are exactly alike, and therefore the scientific treatment of the affection should include a knowledge of the various methods for ascertaining the abnormal mental and physical conditions giving rise to the affection. In other words, as in faulty machinery of any kind, the weak points should be found and the remedy applied directly to them.

The normal automatic action of the organs must be restored, and this can be accomplished only by slow stages through the intermediation of voluntary action. The patient must first learn to recognize, through the auditory and perceptive centres of the brain, the nature of normal speech, and then he must learn to recognize the sensations attendant upon the motor processes of speech.

G. Hudson Makuen.

LAS CRUCES. See *New Mexico.*

LAS VEGAS HOT SPRINGS.—San Miguel County, New Mexico.

Post-Office.—Las Vegas Hot Springs. Hotel.

Access.—Viâ Atchison, Topeka and Sante Fé Railroad to Las Vegas, thence by branch line six miles to springs. Through Pullman sleeping-cars pass Las Vegas twice a day in both directions. These springs are situated upon the southeastern slope of the Santa Fé range of the Rocky Mountains at an altitude of 6,767 feet above the sea-level. They are about forty in number, and vary in temperature from ice-cold to very hot, the thermal springs ranging from 110° F. to 140° F. The following analysis of the waters of the largest of the latter, flowing 1,250 gallons per hour, was made by Dr. Walter L. Haines, professor of chemistry at Rush Medical College, Chicago:

Spring No. 6 (Las Vegas Hot Springs).

One United States Gallon Contains:

Solids.	Grains.
Calcium carbonate	0.89
Magnesium carbonate	.15
Sodium carbonate	8.38
Potassium carbonate	.28
Sodium sulphate	3.35
Sodium chloride	14.68
Silica	3.50
Alumina	.10
Volatile and organic matter	.32
Lithium carbonate	Traces.
Sodium bromide	Traces.
Total	31.65

In its chemical composition this water resembles in many respects that of the famous hot springs of Toeplitz, in Austria. The water is conducted to a commodious bath house, where, under supervision of the resident physician, all varieties of baths are administered by a corps of competent assistants. The baths are said to have accomplished excellent results in rheumatism, gout, and diseases of the skin and lymphatic system. Mud baths are a special feature and are used in obstinate or neglected cases. This vicinity partakes in a large degree of the magnificent climatic conditions prevailing in New Mexico. The average humidity of New Mexico, as shown by the recent reports of the United States Signal Service, varies from 29 to 43 per cent. according to locality—as compared with 72 per cent. for New York City, 73 per cent. for New England, 74 per cent. for the Middle Atlantic, and 79 per cent. for the Southern Atlantic States. The climate here is peculiarly adapted to persons afflicted with hay fever, bronchial asthma, and most forms of throat and lung diseases. The rarity of the air, caused by the high elevation, renders this region unfavorable for cardiac affections. Among the many attractions surrounding the Las Vegas Hot Springs may be mentioned the magnificent mountain scenery, the beautiful drives, and the unrivalled opportunities for fishing and hunting. The Montezuma is a first-class hotel, affording comforts and conveniences to meet the most exacting demands. It has accommodations for 250 guests.

James K. Crook.

LATERAL CURVATURE OF THE SPINE; SCOLIOSIS.—The various definitions of lateral curvature fail of their object in so far as they limit themselves to a description of its superficial features and do not emphasize those which are fundamental to the condition. All distortions of the trunk cannot be classified as scoliosis, but only that type of deformity which has for its distinctive feature a permanent asymmetrical distortion of the spine, in rotation and in lateral deviation, resulting in an asymmetry of the two lateral halves of the trunk. Lateral

curvature may therefore be defined as a permanent asymmetrical distortion of the trunk in which the spine plays the fundamental part.

In its initial stages the deformity differs from the various normal positions of the figure only in the origin of these positions and in the permanency of any given one of them. In the more advanced stages the distortions become more pronounced in character, and their permanency or resistance to correction is caused by the alterations in structure consequent upon the adaptive changes which occur during growth.

FIG. 3161.—Experiment Showing Lateral Bending.

The movements of the spine which are in a pure antero-posterior plane do not produce asymmetry of the figure since the two halves move symmetrically. The movements of the spine which result in asymmetry proceed from lateral bending and torsion, effecting those changes in figure which would come from a displacement of the symmetrical position of any part of the two halves. The changes which occur in lateral curvature may be classed as, first, the spinal or those affecting the spinal column, which may be designated as primary, and, second, the figure contour changes or those which result from the displacement of the spine, and which, therefore, may be regarded as secondary.

We have already said that these changes, both spinal and contour, which occur in lateral curvature, are, in the initial stages, normal in range and direction but abnormal as to origin and permanency. We will now describe what these changes are; and first, as to range and direction.

The two primary changes which occur, namely, lateral deviation and rotation, are distinct and can be studied separately, although clinically they are always found associated. Since, however, they are not always associated in the same relative degree (whence result the various types of curves), it is better for clearness of description to consider them independently.

Lateral Deviation.—The lateral deviation is the bending to one side of the spine, either throughout its entire length or in a limited section. If lateral deviation could be regarded as a pure movement, all parts of the vertebræ would be carried equally to the side, so that a line drawn through the centre of any of the vertebræ would be in the direct antero-posterior plane of the body. This lateral deviation may affect any portion of the spine and to any degree, or it may affect two different portions of the spine each in a different degree and in a different direction. It resembles lateral bending in that it is a movement in the lateral plane; but differs in that it is a bending of a portion of the spine on itself without necessary displacement of either extremity, whereas lateral bending is a bending of the spine to one side on the pelvis, away from the median plane of the body.

Rotation.—Rotation is a turning on the vertical axis of all the vertebræ participating in the curve; the amount of displacement for each vertebra being different, and being greatest at the middle of the curve. The axis of rotation is in about the posterior third of the vertebra, the movement of the anterior part of the vertebra being in the opposite direction from that of the posterior. The length of the anterior portion in front of the axis of rotation being greater than the posterior, the amount of deviation from the normal of the bodies is necessarily greater than that of the spinous processes. The rotation of the spine necessarily involves those parts of the skeleton which are attached to it, as the ribs, and the result may be seen in the shape of the thorax. If rotation occurred as a distinct movement, the axis of its rotation would then remain in the centre of the trunk, the bodies would describe a curve upon one side and the spinous processes a curve of a smaller arc on the other. This rotation, like the lateral deviation, may affect the whole of the spinal column, or only a portion, or two sections in different directions.

Although these two distortions, rotation and lateral deviation, may be studied independently, it must be remembered that clinically they are always associated. Moreover, they are always associated in the same relation, in that the rotation of the bodies is always toward the same side as the deviation of the column.

FIG. 3162.—Experiment Showing Rotation.

It is necessary to remember, in relation to deviation and rotation, that, since the rotation of the bodies is in the same direction as the deviation of the column, the degree of divergence of the body of any vertebra from the

straight line or midline of the trunk, is the amount of lateral deviation of the column at this point plus the amount of rotation; and the amount of departure of the spinous processes from the midline (since the movement in rotation of the posterior part of the vertebra is in the opposite direction from that of the anterior) is the amount of lateral deviation of the column minus the rotation.

Although these two movements are always associated clinically they are not associated in any definite degree or proportion, and since they may affect any part of the spine to any degree and may be associated in different degrees, there is allowed the widest range of variation in the resulting types of curves.

The Secondary or Contour Changes. — The secondary conditions cannot, like the primary, be studied as distinct and definite distortions, since they consist of the displacement of the parts of the trunk and their very great variety does not admit of a definite enumeration. It is better, therefore, to study these with reference to the direction of displacement of the different parts which may be affected. The trunk may be studied in its lateral plane by the position of the head, including the shape of the neck, by the position of the shoulders and scapulæ, and by the line of the thorax, etc.; and in the horizontal plane by the relative prominence of the back at any level, as may be manifested in the dorsal region by the shape and position of the ribs, and in the lumbar by the belly of the erector spinæ muscle. In this way we may map out the method of examining the trunk as follows:

A. Head and neck (as shown by):
- (*a*) Line of trapezius.
- (*b*) Position of head.
- (*c*) Sterno-mastoid muscle.

B. Shoulders.
- (*a*) Level (vertical plane).
- (*b*) Forward inclination (horizontal plane).

C. Scapulæ.
- (*a*) Level (vertical plane).
- (*b*) Distance from the spine (lateral plane).
- (*c*) Distance from the middle of body (lateral plane).
- (*d*) Prominence (antero-posterior plane).
  - (1) Position relative to spine (angle of inclination).
  - (2) Position relative to underlying ribs.

D. Line of thorax.
- (*a*) Shape of side of thorax and waist.
- (*b*) Arm-waist angle.
- (*c*) Relation of lower ribs to crest of ilium.

E. Prominence of two sides.
- (*a*) Dorsal region (ribs).
- (*b*) Lumbar region (transverse processes of vertebræ and erector spinæ muscle).

The above description is equally applicable to changes occurring in the normal or in the abnormal condition since in the normal the same asymmetrical changes, such as lateral deviation and rotation, may be produced by the usual and ordinary movements of the spine.

A further consideration of the affection called lateral curvature leads us to a study of those conditions which

FIG. 3163.—Posterior View of Scoliotic Spine. (Warren Museum.)

FIG. 3164.—Anterior View of Scoliotic Spine. (Warren Museum.)

distinguish it from the normal, viz., its origin and permanency. This permanency is occcasioned by the changes in structure which occur particularly in bone, but may also occur in ligaments and muscle, and they are the result of the altered relations of the parts consequent upon the distortions of lateral deviation and rotation. Since these changes occur during the formative period of growth and conform to those malpositions of the spine which are constantly assumed, they illustrate the law that, during growth, structures adapt themselves in shape to positions in which they are held.

These structural changes may be considered as they are seen in the bones, the ligaments, and the muscles.

Changes in bone are seen in the thickness of the bodies of the vertebræ, these being wedge-shaped instead of having an even thickness; there is also a twist in the antero-posterior axis, so that a straight line drawn through the vertebra does not intersect it into two equal halves. Accompanying these changes in the vertebræ are alterations in the shape of the ribs, consisting of an increase of the angle behind on the side of rotation, and a flattening of the corresponding portion on the opposite side, with an increase in prominence in front, so that the long diameter of the chest is oblique instead of lateral.

Accompanying these changes in the shape of the bony parts of the trunk are the adaptive changes in the length of ligaments, which become shorter on the concave, and longer on the convex sides, thus serving to hold the spine in this position. It is also to be remembered that after long continuance in malpositions there are adaptive changes in the length of the muscles.

Etiology.—Many theories have been advanced from time to time in reference to the etiology of this condition, no one of which is sufficient, and yet each is of value in that it suggests some of the conditions which are active either in the initiation or in the increase of the curve already developed, and a mention of some of these is of importance to show the stages through which this part of the subject has passed. One of the theories was that of unequal growth of bone, advanced by Hueter and Engell, who based their views on the distortion in the vertebræ found post mortem, but which is now known to be a result of growth while the spine is in a false position. Another, advanced by Guérin, was that the distortion was due to a spasmodic muscular action. Tenotomy and myotomy on the concave side have been performed for this, the shortening and contraction of the muscles being mistaken for muscular spasm. Eulenberg upheld the theory of muscular action, but regarded it as an unequal action due rather to weakness than to spasm, believing that, as muscular action is necessary to keep the body erect, if it is defective in one direction, distortion will occur. Although a weakened muscular tone undoubtedly plays a very influential part in some cases, yet in the vast majority unilateral weakness cannot be proved to exist.

Another theory was that of the superincumbent weight, and this theory, urged by Rosa and Volkmann, received much support. It was based on the supposition that the weight of the superimposed parts falling upon the supporting vertebræ, exerted a force which caused the rotation and deviation of the spinal column. Undoubtedly this is a most powerful factor when a curve is once established, but experiments have shown that superincumbent weight placed upon the normal spine does not cause rotation until the spine has already been forced out of position. Moreover, this affection is found in the horizontal vertebrate animals in whom there can be no superincumbent weight upon the spine, and it is also not especially prevalent among the races who are accustomed to carrying weights upon the head. Therefore, this condition cannot be regarded as due to any one factor having a specific action on the spine, but rather as the result of the combined influence of many conditions acting more or less continuously or frequently.

Lateral curvature is a vice of development, and a study of the etiology is the study of the influential factors which result in the development of the asymmetrical instead of the symmetrical form. It is a well-recognized fact that bone, during the period of growth, or in certain pathological states, may be moulded into various unusual shapes by pressure; and therefore if we have, as in

Fig. 3165.—Lateral Curvature after Empyema.

lateral curvature, a condition of plastic bone coupled with a position of distortion of the spine and appendages, either constantly or so frequently assumed as to exert an unequal pressure upon the vertebræ, we have conditions which may result in asymmetrical growth and the formation of a permanent deformity.

Recognizing the fact that one of the essential factors in the development of lateral curvature is the presence of plastic structures, the further consideration of the etiology of this deformity is the study of the conditions which result in the assumption and maintenance of any one malposition by the individual.

The factors which bring about malpositions may be divided into (1) those in which there is a physical defect as an apparent cause, and (2) those in which there is no sufficient physical defect, the deformity resulting rather from many conditions of environment which tend to promote bad attitudes. When the habit of malposture is once established, the factors of muscular weakness and superincumbent weight have a tendency toward exaggerating the condition.

These etiological conditions may be tabulated as follows: 1. Physical defects, such as (*a*) paralysis, (*b*) loss of limb, (*c*) empyema, (*d*) torticollis, (*e*) static defects, (*f*) defective vision, etc. 2. Habits of posture as influenced by (*a*) occupation or recreation, (*b*) general environment (school desks, etc.), (*c*) effect of clothing,

etc. 3. Muscular weakness, and 4. Superincumbent weight, when combined with the above-enumerated conditions.

Among the physical defects may be mentioned those of loss of arm, causing unequal distribution of weight; tho-

FIG. 3166.—Showing the Effect of a Belt on a Slight Curve.

racic disease, as empyema, with incomplete lung expansion, resulting in the unequal development of the two sides of the thorax; static condition, as short leg, giving unequal pelvis; paralysis, giving unequal muscular support, etc.

Among habits of posture are such as standing on one foot, standing or sitting in one position, exercise in a constantly bad position, continued use of one arm, etc. As an illustration of faulty environment may be mentioned the improper arrangement of clothing, making undue pressure upon one or the other shoulder, position of the child's desk with reference to the teacher, improperly constructed school seats, etc.

In the conditions of health and muscular tonicity one finds the habit of malposition much less frequent than in the condition of muscular tire and muscular weakness. It is not to be expected that a young and growing child shall always preserve a correct posture, but, on the other hand, a child does not habitually assume any one particular bad posture without some cause, and so for this reason the factor of muscular weakness becomes etiologically important when combined with those conditions which induce malpostures.

In the same way the factor of superincumbent weight acting upon a spine already in a position of deviation and rotation, furnishes a powerful additional force to the increase of the distortion already established.

The etiology can, therefore, be graphically represented in the following diagram:

Physical defect.
Habits of position. } Faulty attitudes. }

Growing periods.
(Plastic stage.)
Abnormal bone.
(Rickets.) } Soft bone. } Lateral curvature.

Classification.—A convenient classification of these cases is based upon the stage of their development, since the process is a continuous one and the case represents like conditions in all the phases of its course, showing a difference only in the degree of severity. The record of the case gives the location and character of the distortion, and it is not necessary, therefore, to resort to an arbitrary classification in order to define the location of the deformity. Although this division into stages must be more or less arbitrary, since the condition is progressive, yet it enables one to record in general how much of a change has taken place, and is of value as an indication for treatment as well as in the prognosis.

We may therefore divide lateral curvature into three stages: 1. The postural, in which the curves are flexible and there is no evidence of osseous change; 2. The structural, in which the curves are flexible but in which there is an evident osseous change; 3. The fixed curves of marked severity, in which there is little or no flexibility.

The conditions found in the different groups are: 1. Postural; showing (*a*) slight changes in contour, (*b*) slight degrees of lateral deviation and rotation, (*c*) easy correc-

FIG. 3167.—Showing the Condition in a Postural Case of Lateral Curvature of the Spine.

tion or over-correction, (*d*) asymmetry in flexibility. 2. Structural; (*a*) pronounced changes in contour outline, (*b*) permanent lateral deviation and rotation of the spine, (*c*) correction and over-correction not possible, (*d*) evidence of bone changes. 3. Fixed; (*a*) marked contour changes,

(*b*) extreme degrees of lateral deviation and rotation, (*c*) correction not possible, (*d*) evidences of extreme bone changes, (*e*) inflexibility.

Age of Appearance.—Congenital cases have been reported. They are, however, so very rare that they are accounted more as curiosities than of importance, and are usually associated with ante-natal rickets, or else with some other congenital defect, such as the absence of ribs or other general malformations. A certain number of instances are brought to the physician's notice in infants of the age of a few months. In the majority of these cases it is found that the deformity is caused by holding or carrying the child in one position, so that it is practically moulded into this shape. As an instance of this may be mentioned the case of an infant of six months, with a distinct lateral curve, which was apparently caused by keeping the child during the greater part of the day propped in the corner of a sofa, the curve of the spine fitting the position it assumed while in this place.

FIG. 3168.—Showing the Condition in a Structural Case of Lateral Curvature of the Spine.

In the majority of instances the cases are brought to notice during the period of rapid growth. Different statistics which have been collected with reference to the time of appearance apparently group themselves into two periods, that of the first growth, about the age of eight or nine, and that of the second, between the ages of eleven and fifteen, depending somewhat upon the sex. Undoubtedly many of the cases really date from a time previous to their discovery, but since an increase is more likely to occur at a time when the structures are in the most plastic condition, and at a time when the strength of the child is taxed by the process of growth, it is natural that the affection should be first recognized at such time. One may look for the rapid development of the curves during these times of growth, and for a decrease in the rapidity of their progress after the period of growth is over and the bones have become hard.

Influence of Sex.—By far the largest number of cases are found in girls, and this is undoubtedly due to their more restricted environment, to their less general participation in athletic exercises, and to their weaker muscular condition. The deformity is often seen, however, in robust boys, frequently among those who are devoted to a special form of athletics, and such cases often develop to an unusual degree of severity.

SYMPTOMS.—The subjective symptoms in this affection are, as a rule, slight, and more frequently there are none. They are sometimes seen in the severer cases in which the unequal distribution of weight would seem to play a factor, giving a greater muscle strain and muscle tire. When present they usually consist of easy fatigue and irritability, and are such as would ordinarily accompany a general muscular insufficiency, rather than a particular spinal lesion. At times, however, in cases with very marked deformity, pain referred to the concave side is a troublesome feature.

Record.—In the recording of lateral curvature there are two features to bear in mind, first, the changes in the contour of the figure caused by relative displacement of parts, and second, the changes which are seen in the spine and the bony framework of the trunk. It is best to keep this distinction in mind, since in the one we need only graphic reproduction to show the character and general amount of such change, while in the other we must take as accurate measurements as possible to show the amount of departure from the normal. Records may be taken in either the standing or the lying position, each having its advantages, and each being of value both for itself and for comparison with the other.

FIG. 3169.—Showing the Condition in a Severe Fixed Case of Paralytic Origin.

The upright position, in that it is the usual position and represents the greatest curve, gives the more practical record. On the other hand, the conditions in standing

bring in the element of fatigue, muscular action, voluntary effort, superincumbent weight, etc.—factors which are more liable to vary at subsequent measurements. The recumbent position gives a record under conditions less liable to variation and easier to reproduce. The curve is, of course, least marked when the patient assumes this position, but the record is for this very reason not the one which represents the real deformity. The difference in measurements taken by the two methods is approximately an indication of the amount of flexibility.

The problem is to put into some graphic form the various changes which occur, and methods too numerous to mention have been devised for this purpose. All methods have an element of error and bring in the factor of personal skill, and since it is a measurement, not of a mathematical certainty, but of a condition changeable within certain limits, it is well to have a number of forms of graphic representation from which an average may be taken. All the methods may be gathered under a few groups according to the principles which were used. These groups are: (*a*) Measuring machines, (*b*) outline tracings, (*c*) photography, and (*d*) measurements.

Measuring Machines.—Of these that of Zander may stand as the type, being the most complete. The method used in machines of this kind consists in some means of fixing the patient in position by clamps to prevent any movement while the measurements or tracings are being taken, and some device for recording by measurement the relative position of the parts, and transferring the results in such a way to paper as to have a reproduction in drawing of the trunk in either a full or a reduced size. These machines are complete and accurate, but they are expensive and demand some skill in manipulation, which is particularly needed in any device using clamps to fix the patient, the danger being that of displacing the patient from his natural position.

Outline Tracings.—Of this the Pantagraph is the best illustration and consists of a device by which the movements of the recording pencil drawn over the patient are reproduced on paper. Other forms of the same method are that of the old-fashioned lead tape, and such tracing machines as that of Weigel which is used only for rotation. These have the advantage of being simple and inexpensive and of not requiring any special skill in their use, but movement on the part of the patient when the pencil is drawn over the skin is apt to impair the accuracy of the record.

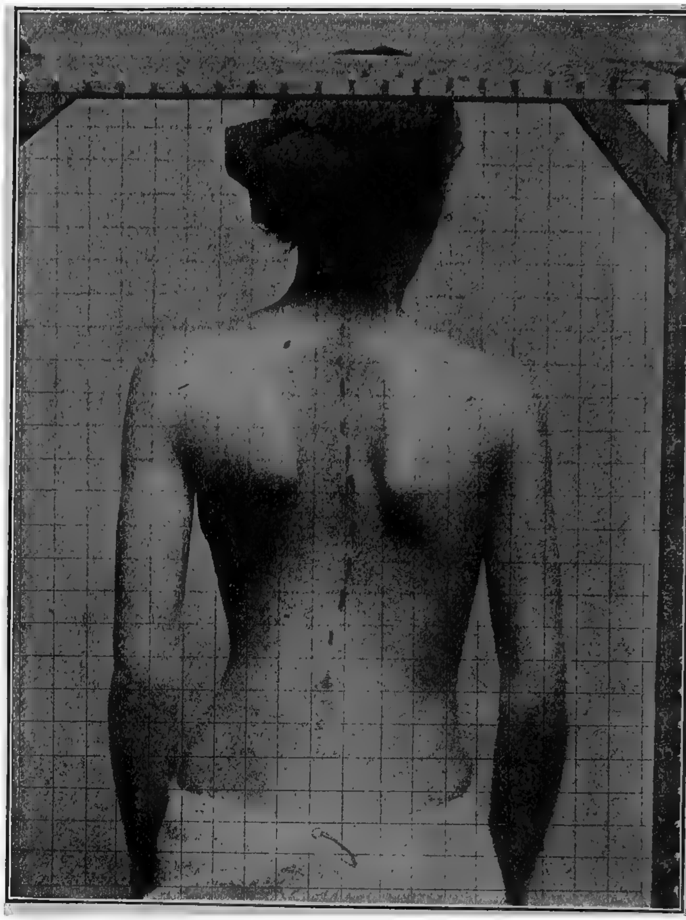

FIG. 3170.—Record by Photography with Screen.

Photography has certain advantages to recommend it for general use. It gives all the outlines of the figure and the deviation of the spine which is obtained by other methods. It enables the record to be taken without the clamping of the patient in position, and it has the advantage of rapidity so that the element of muscular fatigue does not come in. If a screen is placed behind the patient, this can also be used for the measurement of such deviations as are in the lateral plane. It is necessary, however, to have the patient stand directly in front of and perpendicular to the camera, otherwise the view is a combination of the back and side positions.

The method of *measurement* is restricted to the recording of the displacement of such bony prominences as can be measured, and is, therefore, practically a measurement of the deviation of the spine as is shown by the line of the spinous processes. This can be measured either as the deviation of the spine from a line drawn between its two extremities—as, for instance, the seventh cervical vertebra and the fold of the buttock, showing the deviation of the spine from its own axis; or it can be measured as the deviation from the plumb line intersecting one extremity of the spine, showing both the deviation of the spine and the amount of displacement of the shoulders on the pelvis.

A record is made of the point at which the spine leaves the straight line, its point of maximum departure, and its point of return; and in the case of a double curve the lower one is measured with reference to the same points. These points may be designated either by the number of the vertebra or by measurements in distance from any fixed point, as, for instance, the seventh cervical vertebra above or the level of the posterior spines of the ilium below. The advantage of this latter is, that in those cases in which it is difficult to count the spinous processes, one has a more ready and practical method of comparing subsequent tracings.

The methods used by different individuals must necessarily vary according to the means at hand and to the individual's preference. When the more expensive and accurate machines can be had there is no question about the advisability of their employment; otherwise it is best to use the means at hand which are most applicable and with which the individual is most familiar.

As an illustration of a practical method the following may be given: Record the outline changes by photography, either with or without the screen. Measure the

distortion of the spine from either the plumb line or the midline drawn between the two extremities. In either case the point of departure from the straight line is noted and recorded, both by its distance from a fixed point, as, for instance, the seventh cervical vertebra, and also by the number of the vertebra; the point of greatest deviation of curve and the point of its return to the midline are also to be recorded in the same terms. If two curves exist, the second is measured in the same way as the first. These measurements are taken with the patient in the erect and in the recumbent positions, the difference between the two results indicating the amount of natural flexibility of the curve. Rotation, as shown by the prominence of the ribs, is recorded by outline tracings taken perpendicular to the horizontal, reproductions of which in stiff cardboard may be verified by application to the body of the patient. Rotation also may be recorded by the goniometer, a machine for measuring the angle of inclination of the most prominent and of the most depressed portions of the trunk at any given section.

Treatment.—The rational treatment is based upon the application of certain principles to meet needs found in the individual case. In general these needs are uniform and may be said to be, first, an increase in flexibility, so that a straighter position is possible, and second, the maintenance of this improved position by whatever means is most practicable, whether it be that of muscular development, or retention by apparatus, or both.

The treatment should always have a definite object in view and involves the consideration of (1) the various needs to be met, and (2) the means by which these needs may be met. The application of the principles to the individual case will necessarily vary with the facilities at hand.

The measures which may be used in the treatment of lateral curvature are: (1) Preventive. (2) Forcible correction for the increase of flexibility; (*a*) mechanical or passive, (*b*) gymnastic or active. (3) Gymnastic exercise for muscle building; (*a*) for definite weak muscle groups as in paralysis, (*b*) for general improvement of muscle strength (muscle insufficiency), (*c*) for readjustment of muscle control. (4) Apparatus; (*a*) preventive of faulty attitudes, (*b*) retentive, by the application of pressure to retain improved positions; (*c*) corrective application of force constantly applied to maintain correction, as plaster jackets applied with forcible correction.

Preventive Measures.—These may be considered with reference to the correction of any physical defect, such as short leg, torticollis, etc., since it is necessary to counteract the influence of any such existing permanent factor. Also with reference to the correction of any conditions in the environment of the child, as improper clothing, school desks, etc., which will tend to induce habits of malposture. In this connection the question of school seating in its effect upon the growing child deserves especial consideration.

Forcible Correction.—Forcible correction has for its object the increase of flexibility in definite regions of the spine and in a definite direction, in order to make possible a straighter position of the spine. The principle is the same as that employed, to an exaggerated degree, by contortionists and stage dancers, and is based upon the fact that structures which are rhythmically stretched become lengthened.

The mechanical (passive) correction has for its principle the application of pressure through some mechanical force, and in that it eliminates the body weight and muscular antagonism it has the advantage of being directed more definitely toward ligamentous stretching, and it also allows the application of the force more accurately, both as to its direction and as to the amount used. An example of machines of this kind is that of the screw pressure first originated by Hoffa. In such the patient is partially suspended, the hips and shoulders are held by clamps, and the pressure is applied over any part of the trunk in any direction that is desired, with counter-pressure exerted in front at the proper places so as to exert a lateral or rotating force. It is necessary in this that the two ends of the curves shall be fixed as nearly as possible, that there shall be a certain amount of suspension, and that the rotation pressure shall have its counter-points in such places as shall not cause compression of the chest.

The employment of apparatus for increasing flexibility has been carried to the point nearest to perfection by Schulthess, who has devised numerous machines for the application of pressure, some of which employ the principle of the pendulum movement in which the weight of the body is used as an additional force either to make pressure or to bend the spine at any desired point.

Gymnastic (active) correction involves forcible muscular action combined with gravity, so that the momentum of the weight of the body is used as a force to carry the bending beyond its natural limit. This has a wider range of practical usefulness in that it does not require a complicated apparatus. On the other hand, its application is less localized to any particular part of the spine, and it is less manageable, as regards both the amount and the direction of its force.

Fig. 3171.

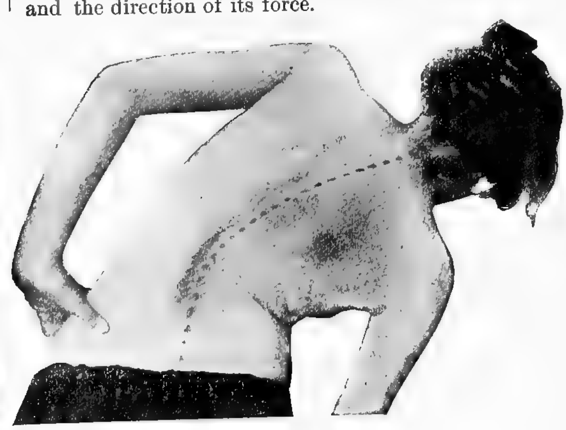

Fig. 3172.

Figs. 3171 and 3172.—Showing Unequal Flexibility.

In either of these two methods the object is to increase the flexibility of the spine in any special area so as to increase the amount of possible bending toward the position of correction.

Gymnastic Exercises.—These may be given for the strengthening of definite weak muscle groups, for general muscular improvement, or for readjustment of muscular control. For the accomplishment of this, gymnastic

exercises may be given either without apparatus, dependence being placed upon the free movements of the body and forced muscular contraction, as in the Swedish methods, or with apparatus—weights and bars, bells, etc., but it would seem that less depends upon the method which is employed than upon the use that is made of it. In other words, the character of the work is of more importance than the method chosen.

The rapid muscle building by the heavy method such as advocated by Teschner has for its principle rapid muscle exhaustion by the use of heavy weights, pushing the muscle to its fully exhausted point as rapidly as possible, and is used in the training of heavy athletes in severe contests. By the use of this method the groups of muscles which are exercised are exhausted before the individual is generally tired, so that recuperation is rapid, while if the equivalent of muscle force were expended in exercise with lighter weights it would require so much more time to exhaust the muscle that the individual would feel this exhaustion in a general way and the recuperation would be less rapid. This method of rapid muscle tire is accomplished by exercise with heavy dumbbells and heavy bars.

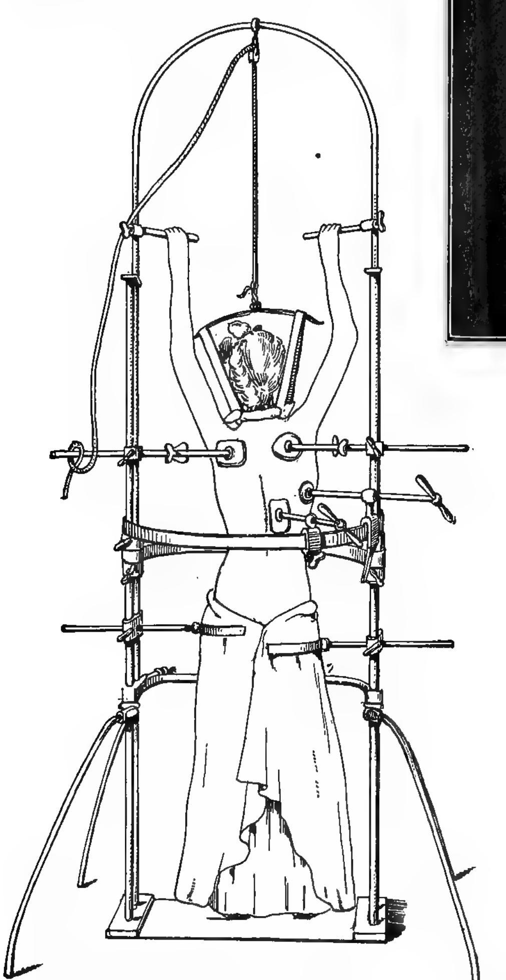

FIG. 3173.—Modified Hoffa-Schede Appliance for Correction by Pressure.

Gymnastic Exercise in Correction.—By this term is meant that form of exercise in which the patient is taught a correct standing position, and is then made to

FIG. 3174.—Showing Attitude in Keynote Position.

hold such a position during the time of the exercise, which is discontinued as soon as this position is lost.

It is a recognized fact that the muscles become accustomed to positions in which they are used, as is seen in those professions in which some malposition is assumed, and the muscles become either shortened or lengthened by such use. This is also seen in cases of lateral curvature when the individual has become so accustomed to the position of distortion that when placed in a straight position he at once expresses himself as feeling "crooked." If all exercises are carefully carried out in a corrected position the results will necessarily be more beneficial.

This method of exercising in a corrected position may be maintained by mechanical means, accomplished either by straps, by apparatus with the screw pressure, or by the manual retention in which the patient makes effort against resistance; or it may be maintained by placing the patient in those postures which tend to straighten the spine, and then giving resistive work in this position. This method is advocated by Roth under the name of "keynote" positions, or those by which an improved position of the back is brought about both by the mode of standing and by the position of the arms. In such attitudes the patient is made to exercise the muscles by resistive movements.

The disadvantage of this method is that it necessitates an artificial position on the part of the individual while exercising and thus does not help in the training of the

maintenance of the improved position by voluntary control.

The position of correction, however, may be a voluntary one maintained by the patient's unaided effort, with the object of training the muscles to a maintenance of the desired position. At first the effort of holding an improved position must be purely a voluntary one, but by education, through the constant exercise in this effort, it becomes more involuntary, and in consequence the position is maintained with greater ease.

The kind of gymnastic exercise used for the development of the muscles is not so essential as the character of the work. One may use the lighter forms of gymnastics, depending upon the body movements with forced muscle contraction, or the lighter forms of weights and pulleys, or, if desired, the severer forms of exercise with heavy weights with the aim of accomplishing the muscle development more rapidly. The essential of all is that the position of self-correction or over-correction should be held during the time of the exercise, and that the exercise be discontinued when the patient is so tired that it is impossible to keep it longer.

Method of Conducting the Exercises of Self-Correction.—It is essential to correct as much of the faulty position as the patient's flexibility will allow, which is done by observing the amount of the displacement of the head, shoulders, and scapulæ, and the sagging of the trunk from the lateral deviation, and then teaching the child to take the improved position. This is done not only by instructing the child in the points to be corrected, but and this may be accomplished by first encouraging the effort toward straightening the spine, by telling the patient to make himself tall, which must be done without raising the shoulders. Then, in order, the position of the head, the level of the shoulders, the relative position of the scapulæ, and the displacement of the shoulders over the pelvis are corrected, and the patient is encouraged to hold this improved position by his own effort. After being allowed to relax, he is again put in the same position and exercises are given while the correct position is maintained. Care is taken that as soon as the child relaxes from this position in any particular the exercise is stopped, until the position is again resumed.

The first grade of exercises in the position can be taken with the arms moving in the lateral plane which displaces the position least of all, and bells may be used or manual resistance made according to the patient's strength. The next stage consists of exercises in the forward as well as the lateral plane, the two being combined, which necessitates a greater effort on the part of the patient to hold the back in the new position. The third stage consists in having the patient change the position of the feet, as in the Swedish fall-out position, so that the centre of gravity of the body is changed, and then go through with the same exercise with the arms and with the moving of the trunk on the pelvis, and returning to the standing position while holding the back in correction.

It is seen that, at first, a patient is able to hold by his own effort a much better position than that which he is able to take voluntarily, but it soon becomes possible for

FIG. 3175.—Lack of Symmetry in Contour in Lateral Curvature of the Spine.

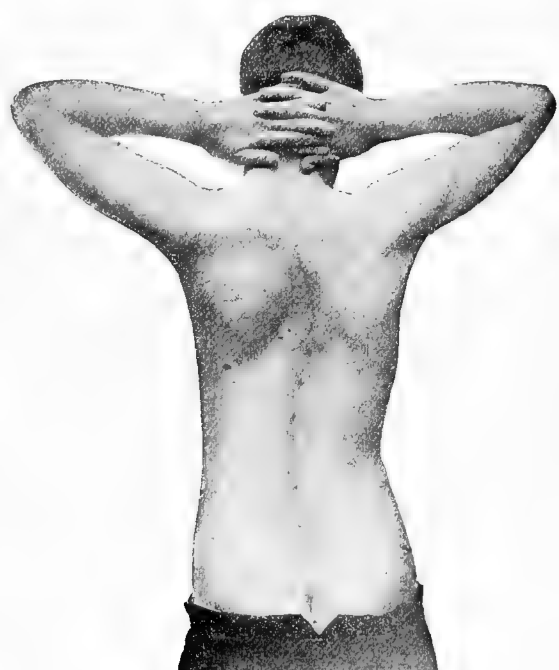

FIG. 3176.—Showing Effect of Effort to Straighten the Spine.

also by manually placing him in a better position. It is a fact that a better position can be held than it is possible to take unaided.

The various methods of conducting a case are so numerous that it would be impossible to give a detailed description of them all, and, therefore, in this article an attempt will be made to describe only one which will serve as an example of the corrective form of exercise.

The first step is the taking of the improved position, him to take this same position and to hold it himself during the exercise. It is necessary that the person should not keep the muscles of the whole trunk rigid during the exercise, but should localize the effort upon the spine. To this effect the patient is made, between any two forms of exercise, to relax all muscles with the exception of those which hold the spine in position, and between any two movements of each exercise he makes an additional effort to straighten the spine.

Apparatus.—Apparatus has for its object either the prevention of faulty attitudes, or the retention in improved positions, or else the application of a force constantly exerted to maintain correction beyond the point of flexibility.

The use of apparatus in the first two instances is to supplement other treatment. If one could be sure that, after an increase of the flexibility by the methods of forcible correction, the improved position would be held by muscular action, there would be no need of further retention. If, on the other hand, exercise treatment can be carried out but a short period of each day or less, and during the remainder of the time the child is continually assuming its habitual malpositions, there is then evident need of some means of retention during the interval.

When used for the first object, that of preventing faulty attitudes, the apparatus should be very simple, and no attempt should be made to exert pressure, its use being rather as an aid or as a reminder. It may be that only a crutch, fastened to the child's waist to prevent the dropping of the shoulder, may be necessary, or a light upright to prevent the child from sagging either in the antero-posterior or in the lateral direction. In any case it should be adapted to the individual need.

When applied for the second object, that of retention, the aim of the apparatus is to hold the patient in a better position than he can maintain by his own unaided efforts. In these cases as much force as is compatible with the patient's comfort is used and is applied either in the antero-posterior or the lateral plane. In this the pressure must always be made over the points of greatest curve, and there must be two points of counter-pressure on the opposite side well above and below the limits of the curve. In other words, counter-pressure in the concavity of the curve must be carefully avoided.

Apparatus for the object of correction consists of the employment of a plaster jacket applied in the over-corrected position. Such a method is applicable in the treatment of patients who come from a distance, or who for other reasons are unable to carry out a definite and continuous treatment, and it is also adapted to those cases which require more forcible stretching than can be carried out by the gymnastic method. The method consists in the application of a jacket while the patient is in either the recumbent or the semirecumbent position, pressure being made over the points of convexity, while by means of clamps the hips and shoulders are fixed in the desired position and counter-pressure is applied. This affords a most satisfactory method of treatment for the severer cases which can be helped by no other means, and also for improving the condition in the lighter forms of the structural cases, as preliminary to the later use of gymnastic exercises with some form of removable apparatus.

This method has been most thoroughly practised by Wolfstein. His method is to employ the forcible staightening for the increase of flexibility as preliminary treatment, and then to encase the patient in plaster from the pelvis, including the head. The method as practised by Wolfstein is effectual, but is so severe that it can be carried out only in selected cases. As ordinarily practised, however, it has a wide range of application.

Elliott G. Brackett.

LAUGHING may be defined as an expression of mirth by means of altered facial expression and a series of forcible intermittent expirations with the production of characteristic inarticulate sounds. When excessive it is accompanied by lachrymation. Although an involuntary act, it is to such an extent under control of the will that ordinarily it may be suppressed or rendered inaudible. It is imitated with difficulty.

Laughing is peculiar to the human species. Some of the lower animals and birds have the power of producing sounds like those of laughter, but the facial expression is lacking and there is no evidence that the sounds are employed to express mirth.

In point of time the respiratory movements are preceded by the change of facial expression, the smile. This consists for the most part in an elevation of the angles of the mouth, an increased prominence of the cheeks, and slight elevation of the outer extremities of the lower eyelids; the mouth is then opened and the explosive sounds begin to issue from it. A series of a more or less distinct "ha-ha" is the usual audible expression, and the word itself has been adopted by the North American Indians to signify laughing:

> "And he named her . . . Minne-ha-ha, Laughing Water."

Laughing varies much in character in different individuals and in persons of different nationality, and there is a no less difference in individual propensity to laugh. Some seem to possess an instinctive inclination to laugh, while others are so morose as rarely to enjoy it. Some never laugh beyond moderation, others are all but too readily thrown into paroxysms.

The impulse is generally received through the sense of sight or that of hearing, but more susceptible persons may be moved through any of the other senses, especially by tickling or even by suggestive motions and not infrequently by their own thoughts and recollections. To a certain extent a person's laughter, and still more his susceptibility to it, is an index to his character, for a lack of control in this regard may signify weakness in other faculties. Loud laughing is looked upon as rudeness in a woman and tittering is indicative of effeminacy in a man. A good, whole-souled laugh is generally a passport into society; its counterfeit is readily recognized. But laughing may become so impulsive, even in one not abnormally excitable, as to be for a time at least entirely beyond control. In a fit of laughter, a person may lose all muscular control, even the ability to stand. He sits with his head thrown back, the limbs extended, the arms hanging limply at the sides, while his whole frame shakes; shouts and screams issue from the widely opened mouth, and tears trickle down from the half-closed eyes; an unfortunate relaxation of the sphincters sometimes occurs. A happy, vigorous child will roll upon the floor in paroxysms.

There is also a sympathetic influence in laughter; we say that it is infectious, for one person will frequently incite it in many others who do not so much as know the cause of the merriment. So intimate is the relation between laughing and crying that one may quickly succeed the other or insensibly merge into it. In the hysterical seizure, laughing and crying are interchangeable modes of expressing the abnormal emotions. Under the influence of mixed emotions or great excitement, sobs may suddenly give place to violent laughing, as was illustrated in Victor Hugo's character, Gwynplaine; or sounds may be emitted which can with difficulty be distinguished as belonging to one or the other class.

The impulse to laugh may be intense, concentrated, or diffuse and cumulative. The more intense the impulse, as a rule, the more violent is the outburst, but the enjoyment may be no greater. More pleasure may be experienced, for example, in the possibly silent laugh which follows the reading of a humorous description with suitable climax than in the sudden outburst at sight of something ludicrous. Laughing is not devoid of inherent pleasure, yet few ever laugh simply for the pleasure of it, except as the child that asks to be tickled. Real laughing is in fact impossible in the absence of a proper stimulus.

The nervous mechanism of the act is not fully understood. Like that of crying, it is probably not under control of a single nerve centre, but rather under the group of centres concerned in respiration and facial expression. All the muscles of respiration are doubtless involved, but more particularly those of the diaphragm. The act consists of a succession of rapid contractions of the diaphragm with more or less forcible expulsion of the air from the lungs through a widely opened glottis, the vocal bands being held tense. The sound is often produced in part also by the vibration of other tissue folds in the larynx and pharynx. The muscles of the face concerned are chiefly the several elevators of the angles of

the mouth and of the lower eyelids and to some extent the orbiculares oris and palpebrarum. By voluntary effort, however, other muscles may be brought into play for the expression of wonder, surprise, or even of disapproval, astonishment, or disgust.

Benefit is unquestionably derived from laughter. Every physician is sensible to its influence upon his patients, for "A good laugh is better than medicine." The fact that fleshy persons are generally hearty laughers has given rise to the adage, "Laugh and grow fat," but it is probable that both these qualities are favored by the same temperament.

Laughing becomes difficult or impossible in paralysis or painful affections of the respiratory muscles and in inflammatory affections of the thoracic or abdominal tissues or viscera. An inability to laugh, in the absence of such conditions, is often a valuable indication in symptomatology, for, although a person who is seriously ill is naturally disinclined to mirth, persistent disinclination may indicate to the physician some mental distress, lasting, poignant grief, a pricking conscience, or domestic infelicity. The neurasthenic patient is slow to laugh and nothing more certainly indicates improvement than a restoration of this faculty.

The overexertion attendant upon an uncontrollable paroxysm is not devoid of danger. Death has repeatedly occurred, probably from cerebral hemorrhage or rupture of the heart or of an aneurism induced by it, and it is stated that the death penalty has been executed by means of tickling. *James M. French.*

LAUREL.—Royal Bay. The true Laurel of Europe, *Laurus nobilis* L. (fam. *Lauraceæ*) is a handsome, fragrant-leaved evergreen shrub or small tree, from two to six metres in height, with numerous slender, smooth, green, very leafy branches, and dark-green, shining, leathery, oblong-lanceolate or lanceolate, entire, but often wavy or slightly revolute-margined leaves, and producing an ovoid berry, with soft flesh and a large, fleshy seed.

This laurel is a native of Asia Minor and Syria. It has long been grown in and is probably a native also of Greece and the islands of the Eastern Mediterranean. Further, it has been cultivated in Italy, at least as long ago as the days of classic Rome, and in the southern part of Europe generally, in England for several hundred years, and recently in Mexico and the West Indies. It is supposed to be the plant dedicated by the ancient Greeks to Apollo, and regarded by them as an emblem of purification, peace, victory, and good luck in general. It is the laurel of sculpture, painting, and literature. The leaves have been described in the article entitled "*Bay.*" The fruits are about 1 cm. long ($\frac{2}{5}$ inch), and when dried are dull-brownish-black, slightly withered, with a brittle papery exterior and a brown, smooth kernel, splitting easily into two large cotyledons. Odor peculiar, strong, spicy; taste balsamic and bitter.

The fruits are rich in fragrant and fatty constituents, the latter principally in the embryos. The *essential oil* (0.23 per cent.), a colorless or yellow liquid, gives them their odor. The *fatty oil* is obtained by pressing or boiling; it is a yellowish-green, buttery soft-solid, fragrant with some dissolved essential oil; it is soluble in ether, but only partially so in alcohol. Laurel fat is a composite substance, consisting of glycerides of oleic and stearic, as well as palmitic, myristic, lauric, and probably other, acids. The leaves, which are used abroad as a kitchen flavor for soups, etc., contain *essential oil, tannin*, a bitter substance, etc.

Action and Use.—The leaves and essential oil have no peculiar action to distinguish them from other fragrant substances (see *Cinnamon*, for instance). The impure fat of the seeds is moderately stimulant to the skin, and is used as an ointment in rheumatism, paralysis, etc., internally as an aromatic. It is a medicine of great antiquity, but at present it is nearly obsolete so far as the practice of physicians goes. Neither the fruit nor the leaves have any consumption in the United States. Certain brands of "stick liquorice" are packed in Bay leaves.

Essential Oil of Laurel is an article of commerce, and, except for refined distinctions as to odor, etc., is the same from both fruit and leaves. The latter has a specific gravity of about 0.924, the former 0.925. The principal constituents are pinene and cinene. *W. P. Bolles.*

LAVENDER.—Lavandula; *Lavandula angustifolia* (L.) Miller (fam. *Labiatæ*). A perennial, partly shrubby plant, with short, crooked, branching stems, and numerous slender, upright, simple branches, from one-third to more than one metre in length. Leaves opposite, linear with entire, slightly revolute margins. Flowers in small opposite cymes, closely aggregated into spike-like clusters at the ends of the slender branches. All the green parts, calyx, branches, and leaves, are covered with a tomentum of stellate hairs and stalked glands. Calyx tubular-ovoid, with only one lobe (the upper) developed. Corolla tubular, curved, with spreading two-lipped border, lobes of both lips rounded, those of the upper longer and straighter than those of the lower, color pale violet; stamens four, inserted in the corolla tube, ovary four-celled and four-seeded. Lavender is a native of the southern part of Europe and the northern border of Africa, growing in elevated and dry places. It has also been cultivated for centuries, and the herbage, flowers, and oil are all in the market.

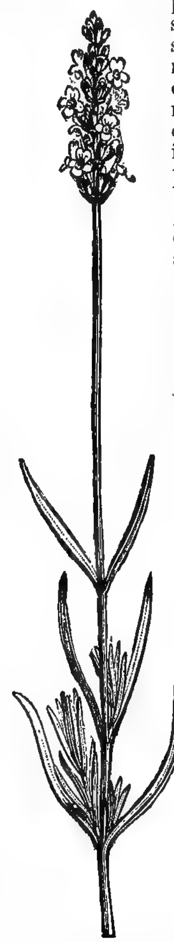

Fig. 3177.—Flowering Stem of Lavender. (Baillon.)

Fig. 3178.—Lavender; Single Flower. (Baillon.)

The flowers, dried, are about 5 mm. long ($\frac{1}{5}$ inch), of a general blue-gray color, with very hairy calyx. The retention of the bright blue color of the flowers is an indication of careful drying, freshness, and fine quality. The fragrance is delightful, the taste bitterish, aromatic, somewhat camphoraceous.

Composition.—Lavender flowers contain about one or one and a quarter per cent. of *essential oil*, which they retain, if properly kept, for years; the stems also contain a similar but less agreeable oil. With this oil there is a little tannin and resin.

Action and Uses.—The action of lavender is purely that of an aromatic stimulant and carminative, like its relatives in the family. Its odor is highly esteemed by almost every one. It is not strange, therefore, that aside from the oil, both the plant and the flowers should have an extensive use, especially in domestic practice. Both have been official in our own and other

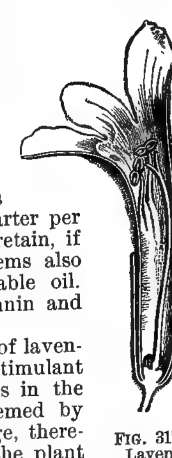

Fig. 3179.—Lavender; Longitudinal Section of Flower. (Baillon.)

pharmacopœias, but professional use is now almost entirely restricted to the oil, which is described below. The dose of lavender is 1 to 4 gm. (gr. xv.–lx.) corresponding to about one minim of the oil, though the latter is given in larger doses.

LAVENDER, OIL OF. OLEUM LAVANDULÆ FLORUM (U. S. P.). Both the oil of the plant and that of the flowers are commercial, and both have been official, though only that here considered is so at present. They are very similar, that of the flowers being only a little finer. The official article is thus described:

"A colorless or yellowish liquid, having the fragrant odor of lavender flowers and a pungent and bitterish taste. Specific gravity 0.885 to 0.897 at 15° C. (59° F.). It is soluble in all proportions in alcohol (distinction from *oil of turpentine*) and in three times its volume of a mixture of three volumes of alcohol and one volume of water (distinction from and absence of *oil of turpentine*); it is also soluble in glacial acetic acid. With an equal volume of carbon disulphide it forms a turbid mixture. The alcoholic solution of the oil is neutral or slightly acid to litmus paper. When heated on a water-bath, in a flask provided with a well-cooled condenser, the oil should yield no distillate having the odor of alcohol."

A number of inferior oils, from other species of lavender, chiefly spike oil, from *L. Spica* Cav., are in the market and are all distinguished by their much higher specific gravity, that of spike oil, the highest, ranging from 0.905 to 0.920.

The active portion of oil of lavender is *linaloyl acetate*, which should constitute about one-third of it.

The dose of lavender oil is ♏ i. to v., though it is comparatively little used internally. The official spirit has a strength of five per cent. The compound tincture, or compound spirit, contains, with 8 parts of this oil, 2 of oil of rosemary, 20 of cassia, 10 of nutmeg, 5 of cloves, in a thousand, and is colored with red saunders.

Henry H. Rusby.

LAXATIVES.—This term is applied to all substances which gently evacuate the contents of the intestines. Some authors limit its use to those purgatives which, in large doses, produce normal or nearly normal stools, without obvious irritation. Others extend it to all purgatives which operate without causing decided griping. As generally employed at the present time, the term embraces all medicines and articles of food which render the stools softer and more frequent, without causing any notable irritation. Laxatives are frequently termed aperients, lenitives, and eccoprotics.

Articles of food which cause bulky and loose stools generally provoke daily intestinal evacuations, and hence are called laxative foods. They all contain notable quantities of indigestible matter, and some of them salts and acids, which are supposed to operate in the same manner as the saline laxatives.

The succulent vegetables and fleshy fruits contain much cellulose, which, for the most part, resists digestion, and hence increases the bulk of the fæces, and thus mechanically promotes peristalsis of the large bowel. When they constitute a large part of the diet a daily easy evacuation usually takes place. Many persons, however, cannot eat them in sufficient quantity without suffering from dyspepsia. The most laxative fruits are prunes, figs, pears, peaches, apples, and berries. One or two oranges eaten before breakfast will sometimes cause an evacuation in a few hours.

The most laxative foods are those prepared from the unbolted meal of the cereal grains. Graham bread or brown bread, prepared from unbolted wheat-meal, is generally preferred for continued use, and, when it forms a considerable part of the diet, almost uniformly causes sufficient action of the bowels. Cracked wheat is equally laxative, and is occasionally eaten by persons of costive habit. Oatmeal and Indian-meal are also useful, but are usually less relished than brown bread. Pure bran is sometimes employed as a laxative in quantities of one or two tablespoonfuls daily.

Saccharine articles, such as honey, molasses, and brown sugar, if indulged in freely, usually provoke a daily intestinal evacuation. Sugar of milk, in quantities of from two to four drachms, dissolved in half a pint of warm skim milk, and taken about two hours before breakfast, frequently produces one or two loose stools in a few hours. Some persons procure an easy motion soon after breakfast by drinking a tumbler of cool water immediately after rising.

Generally, laxative foods which cause bulky evacuations increase the appetite. In part this results from the waste of much nutritious matter, which is less completely digested when mixed with a quantity of indigestible cellulose or woody fibre.

Laxative medicines are employed in habitual constipation when a laxative diet and other appropriate hygienic measures have failed to cause regular action of the bowels, or when they cannot be adopted. They are generally preferred to stronger purgatives in acute constipation, unless the latter are required to produce effects on the general system.

Magnesia and Magnesii Carbonas.—In moderate laxative doses these medicines cause feculent stools in from eight to ten hours. They rarely operate sooner than six hours, and often not before twelve to twenty-four hours. Occasionally their action is attended by some nausea and colic. According to Trousseau, the continued use of magnesia may be followed by irritation of the large intestine, the stools becoming mucous and bloody. Its habitual use has been followed by accumulations of ammonio-magnesian phosphate in the colon, which could be felt through the walls of the abdomen. Such concretions may give rise to obstinate constipation, typhlitis, and perforation of the bowel.

Very small doses of magnesia and its carbonate do not act on the bowels, as they form salts with hydrochloric and lactic acid in the stomach, which are completely absorbed. But when larger quantities are taken than can be thus neutralized in the stomach, the excess passes into the intestines, where it is gradually converted into a bicarbonate, which, on account of its low diffusibility, passes into the lower part of the bowels and excites peristaltic action. One gram of magnesia is capable of absorbing 1,100 c.c. of carbonic acid gas; hence it has been used in cases of meteorism, but has not proved very effectual, partly because carbonic acid gas forms only a part of the intestinal gases, and partly because of the arrested peristalsis.

On account of their antacid property, magnesia and its carbonate are indicated when constipation is associated with an excessive formation of acids in the alimentary canal. By combining with the acids they prevent further irritation, and by hastening peristalsis remove the causes of fermentation.

Magnesia is frequently used in infantile diarrhœa when the stools are green in consequence of an excess of acid. Often the diarrhœa ceases as soon as the stools acquire their normal color.

In all cases in which a very gentle laxative is indicated, as in debilitated adults and feeble children, magnesia or its carbonate may be employed.

The dose of magnesia for adults varies from ʒ ss. to ʒ i., and for children from gr. v. to gr. xx. Of the carbonate about one-fifth more may be given.

Magnesia is ordered in the form of powder or mixture. Heavy magnesia is preferred for powders, and is usually taken in milk or sweetened water.

Mixtures of magnesia gelatinize rapidly, unless they contain about sixteen parts by weight of water and four parts of syrup or glycerin. According to Hager, a mixture consisting of one part by weight of magnesia, ten parts of distilled water, and four parts of glycerin, remains liquid for a long time.

Liquor Magnesii Citratis and Magnesii Citras Granulatus.—The solution of citrate of magnesium, and the granulated citrate of magnesium, in moderate doses, act very gently. In the alimentary canal they are converted into the bicarbonate of magnesium in the same manner as calcined magnesia.

Laxatives.

The dose of the solution is ℥ iv.–vi.; of the granulated salt, ʒ ij.–iv.

Certain mineral waters containing notable quantities of sulphate and chloride of magnesium, and sulphate of sodium, especially Friedrichshall and Hunyadi János, are frequently employed as laxatives. They usually act gently, producing thin and watery stools, without griping or tenesmus. Generally they move the bowels in a few hours, but numerous exceptions occur. After a time the bowels no longer respond to them, so that even large doses, which at first operate with considerable energy, soon have little or no effect. The minimum laxative dose varies greatly in different persons, but usually from four to eight ounces act gently and promptly. These waters are said to be useful in habitual constipation depending on simple chronic intestinal catarrh, or on nervous atony of the bowels, as found in hypochondriacal, hysterical, and sedentary persons. Their prolonged use in the constipation of feeble and anæmic patients is injurious.

Potassii et Sodii Tartras.—In doses of ʒ ij.–iv. the tartrate of potassium and sodium, or Rochelle salt, usually produces one or several loose stools in from three to six hours, without colic or tenesmus. On account of its not disagreeable taste and mild action, it is frequently used in the diseases of children and delicate adults, when an aperient is indicated. It is held to be preferable to other laxatives in cases of constipation attended with a deposition of urates in the urine, or with defective secretion of bile.

Generally it is ordered in the form of powders, each ʒ ij., with a small quantity of sugar and oil of lemon. If ordered in solution, fruit syrups should not be added as flavoring agents, as they are incompatible with the salt. When the stomach is irritable, the salt is usually given in the form of *Pulvis effervescens compositus*, or Seidlitz powders. These consist of ʒ ij. of tartrate of potassium and sodium and gr. xl. of bicarbonate of sodium, wrapped in a blue paper, and gr. xxxv. of tartaric acid, wrapped in a white paper. The two powders, when taken, are dissolved separately, the former in about four ounces of water, the latter in one ounce. The solutions are then mixed and drunk while effervescing.

Sulphur.—Washed and precipitated sulphur, in doses of gr. xx.–lx., act very gently and slowly, producing one or two feculent stools, which usually have a strongly marked odor of sulphureted hydrogen. The laxative action is held to be due to the sulphide of sodium formed in the intestines. Some of the sulphide is decomposed by the carbonic acid gas of the bowels, which causes the evolution of sulphureted hydrogen. As only a part of the sulphur can undergo chemical changes, large doses do not produce brisk purgation. After prolonged use of sulphur a disagreeable odor may be detected in all the secretions.

As a laxative sulphur is held to be useful in cases of piles, fissure of the anus, and stricture of the rectum, because it produces soft, easily moulded stools, which pass from the rectum without irritating the highly sensitive parts. It is often combined with other purgatives, such as magnesia, bitartrate of potassium, and senna, but acts well without such additions. The following formula of Brodie's is highly recommended by Cripps as a mild laxative for internal piles. ℞ Conf. sennæ, ℥ iss.; sulph. præcip., ℥ ss.; mel. rosæ, q. s. M. S. About a teaspoonful every night. Usually sulphur is ordered in the form of powder, which may be taken in milk, syrup, or molasses. It should not be ordered in liquid mixture, as it soon firmly adheres to the bottom of the phial.

Oleum Ricini.—Castor oil in appropriate doses usually acts very gently, producing one or two evacuations in from three to six hours. Large doses act more briskly, and often cause nausea and vomiting, with somnolency and a feeling of weakness. If the oil is rancid, small doses may be followed by such effects.

In the duodenum castor oil is decomposed like other oils, and its ricinoleic acid set free. Some authors hold that this acid irritates the mucous membrane and thus excites peristaltic action. Others suppose that an acrid substance, insoluble in water, alcohol, ether, and alkalies, and readily decomposed by heat, is the purgative principle. In experiments on isolated parts of the intestines of dogs, Brieger found that the oil caused firm contraction of the bowel without any appearances of hyperæmia.

On account of its gentle, speedy, and certain action, castor oil is often used when constipation occurs in the diseases of children, in pregnant women, after parturition, and in delicate persons. For the same reasons it is generally preferred to other laxatives when evacuation of the contents of the bowels is required in typhoid fever, dysentery, and other inflammatory affections of the intestines or adjacent organs. It is also suitable to cases of diarrhœa caused by the presence of undigested food or other irritating substances.

It is not appropriate in habitual constipation, as its continued use soon causes disorder of the stomach; and it is contraindicated in gastric catarrh.

The only objection to castor oil is its disagreeable taste, due chiefly to its adhesiveness and viscidity. Various methods of disguising it are in use. Its adhesion to the mouth and throat may be prevented by previously rinsing these parts with an alcoholic liquid. It may be rendered less viscid and comparatively tasteless by mixing it with hot bouillon, hot coffee, or milk, or with the foam of ale or beer, or peppermint water and brandy. Its taste is hardly perceptible when it is mixed with an equal quantity of glycerin and a few drops of oil of cinnamon or gaultheria. Sometimes it is administered in capsules, which, of course, are perfectly tasteless. It is said that the oil is not repulsive when rubbed up into a mass with three parts of sugar, or with two parts of compound powder of liquorice. The latter form is adapted only to adults, the former to children. The mass may be divided into large pills which, placed upon the tongue, can be conveniently swallowed with a draught of water. Sometimes the oil is ordered in emulsion with gum arabic: ℞ Olei ricini, ℥ ss.; pulv. acaciæ, ʒ i.; syrupi, ʒ ij.; aq. menth. pip., q. s. ad ℥ ij. M. ft. emuls. In emulsions of castor oil the gum arabic should not exceed in weight one-fourth of the oil, as it is apt to interfere with the laxative action.

The laxative dose of castor oil for adults varies from ʒ i. to ʒ iv., for children from ʒ i. to ʒ ij. Sometimes a dose of from ♏ xx. to ♏ xxx., taken two hours before breakfast, acts gently in a few hours.

Rheum.—In some persons as little as from gr. iij. to gr. v. of rhubarb causes a feculent evacuation in from eight to twelve hours. In others as much as gr. x. is necessary for this effect. Doses of gr. x.–xv., if repeated several times, usually cause two or three stools in from five to ten hours, each stool being preceded by some griping. The stools are usually yellow and semi-liquid.

If taken habitually, laxative doses of rhubarb soon fail to act, and finally even large doses may have little effect. There are, however, numerous exceptions to this rule, some persons using it habitually for many years without being under the necessity of materially increasing the dose.

Rhubarb is well adapted to the habitual constipation of persons with feeble digestion. Often laxative doses not only produce a daily evacuation, but also increase the appetite and relieve oppression after meals. In the constipation of persons afflicted with piles, gr. v.–x. taken every night, or as often as needed, act well and frequently give great relief. A daily laxative dose is useful also in the costiveness and hemorrhoidal swellings incident to pregnancy.

Rhubarb is often preferred to other laxatives when constipation occurs during convalescence after acute diseases, or in anæmic, cachectic, very feeble, or very aged patients. In icterus also, a laxative being required, many physicians prefer rhubarb. It is used in some forms of diarrhœa, especially when symptoms of dyspepsia are associated with the looseness of the bowels. In such cases only very small doses are given, and the good

effects depend rather upon the bitter and astringent than upon the purgative principle of the medicine. Laxative doses are required when looseness of the bowels is caused by irritating substances, as in the diarrhœa of children when the discharges are green. In such cases magnesia is often associated with rhubarb in order to neutralize the excess of lactic acid, as in the official *compound powder of rhubarb.*

The dose and mode of administration vary in different cases. In habitual constipation one dose of gr. iij.–x. is usually given in the evening. In acute constipation, such a dose may be administered every three or four hours until the bowels move. In diarrhœa with acid stools, small doses are given several times a day.

Rhubarb is rarely administered in the form of powder on account of its disagreeable taste, which may, however, be somewhat disguised by the addition of an aromatic, especially the official aromatic powder. The official pill of rhubarb, containing gr. iij. of rhubarb and one of soap, is usually preferred in habitual constipation, from one to three pills being taken at bedtime. Some costive persons daily chew a small piece of rhubarb, weighing from gr. v. to gr. x., in order to increase the action of the bowels.

Of the liquid preparations, the wine, the simple tincture, and the aromatic tincture, in appropriate doses, are suitable laxatives for convalescent, feeble, and aged patients, and the syrup and aromatic syrup for children.

Aloe.—In doses of gr. ij.–v., aloes usually produces one or two stools in from ten to fifteen hours. Occasionally it acts in six or eight hours, but more frequently its action is delayed beyond sixteen hours. The stools are soft, bulky, and dark. Sometimes they are attended by slight griping and tenesmus. These effects are more marked after larger doses, which also cause the stools to become thinner, but do not act much more speedily than small ones. The persistent use of aloes is sometimes followed by a feeling of weight and fulness in the pelvis, and, it is said, by the development of true hemorrhoids. According to Lewin, delicate young persons and the aged are predisposed to such effects. The slowness of action, and the symptoms of hyperæmia of the rectum, show that aloes influences chiefly the descending colon and rectum. According to the researches of Rutherfold, it increases the secretion of bile and renders it more watery.

Aloes does not usually lose its activity when habitually taken, the same dose producing the same laxative effect for many months, and sometimes for years; in some cases the dose may even be gradually diminished. For this reason it is one of the most appropriate laxatives for habitual constipation.

Aloes is held to be preferable to other laxatives when constipation is associated with dyspepsia, hypochondriasis, and biliary derangement, and, in females, with atonic amenorrhœa. The presence of piles, unless they are inflamed, does not contraindicate the use of laxative doses. But aloes should not be employed when active hyperæmia of the large intestine exists, or when there is some disease of the uterus tending to hemorrhage. And though small doses might do no harm in pregnancy, it is better to resort to other laxatives.

On account of its slow action, aloes is usually taken just before or after the last meal, and, as a rule, it acts on the next morning after breakfast. If it act sooner, it should be taken just before retiring.

As aloes is intensely bitter, it is generally ordered in the form of pills, of which five varieties are official. For all ordinary cases of constipation the *pilulæ aloes,* containing each two grains of aloes and soap, answer well, one pill being given daily. The *pilulæ aloes et mastiches,* known also as Lady Webster's dinner pills, also contain each gr. ij. of aloes and a little mastic; the latter has no effect. The *pilulæ aloes et ferri* are adapted to the constipation of anæmic persons. Some authors state that the sulphate of iron in these pills increases the activity of the aloes. The *pilulæ aloes et myrrhæ* are held to be suitable to constipation associated with atonic amenorrhœa.

Resina Podophylli.—The resin of podophyllum, or podophyllin, as it is commonly called, in doses of gr. $\frac{1}{8}$ to $\frac{1}{4}$, operates slowly, moving the bowels in about eight to twelve hours. Administered in the evening, it usually produces a feculent evacuation next morning after breakfast. Sometimes it causes griping, especially in delicate females. Like aloes, it retains its laxative action for a long time without necessitating an increase of the dose. According to Rutherford and Vignal, podophyllin increases the secretion of bile without altering its composition.

The laxative operation of podophyllin is somewhat uncertain, a dose which acts gently in some persons acting either severely or not at all in some others.

On account of the smallness of its dose, the convenience of its administration, its persistent action in the same dose, and its cholagogue power, podophyllin is much used in various forms of habitual constipation. It is held to be especially adapted to cases of atony or torpor of the muscular layer of the bowel, and to constipation associated with an insufficient secretion of bile. Harley found it very useful in cases of feeble liver, when the insufficient secretion of bile resulted from want of nervous power.

Podophyllin is generally administered in the form of pill. To prevent griping, a small quantity of extract of belladonna or extract of hyoscyamus is incorporated with it, and, when required, some extract of nux vomica. Podophyllin is sometimes dissolved in alcohol and taken in sweetened water.

The active principle of podophyllum, called podophyllotoxin, has been given to adults in doses of gr. $\frac{1}{6}$–$\frac{1}{4}$, usually dissolved in alcohol and taken in syrup or sweetened water. Its action is said to be more certain and regular than that of podophyllin. To children it has been given in doses of gr. $\frac{1}{20}$–$\frac{1}{12}$, according to their age.

Senna.—Senna is rarely given alone as a laxative, but frequently in combination with less active purgatives, as in the official *Confectio Sennæ* and the *Pulvis Glycyrrhizæ Compositus.* Having little or no unpleasant taste and acting very gently, the confection of senna is often used to unload the bowels in pregnancy, convalescence, and hemorrhoidal affections. The dose is one or two drachms, which may be conveniently taken at bedtime. The compound powder of liquorice is adapted to the same cases, and is sometimes used in habitual constipation. It is given in doses of half a drachm to one drachm in a small quantity of water, preferably at bedtime.

Colocynthis.—The extract and compound extract of colocynth are sometimes employed as laxatives in habitual constipation, the former in doses of gr. ss.–i., the latter in doses of gr. i.–v. Generally they are combined with other laxatives, and with extract of hyoscyamus or extract of belladonna, to prevent griping, as in the following pills: ℞ Extr. colocynth. comp., gr. iv.; pulv. ipecac., gr. ij.; podophyllin, extr. bellad., āā gr. i. M. ft. pil. No. iv. Sig.: One pill at bedtime.

Cascara Sagrada.—This remedy has come into general use as a laxative in habitual constipation. Its prolonged employment in appropriate doses is frequently followed by a return of the normal activity of the large intestine. Usually the fluid extract is given in doses of ♏ x.–xxx. several times daily. ℞ Extr. rhamni purshianæ fluidi, Syrupi aurantii, Aquæ destillatæ, āā ℥ ss. M. Sig.: One-half to one teaspoonful three times daily before eating. The dose found to be effective should be gradually lessened. In many cases it may be entirely discontinued after a few weeks or months.

Frangula.—In doses of ♏ xv.–xxx. the fluid extract of frangula is said to be a mild but uncertain laxative. As it does not quickly lose its activity, it has been recommended for habitual constipation. *Samuel Nickles.*

LEAD.—I. General Medicinal Properties of Compounds of Lead.—Absorbed into the system, lead exerts a peculiar influence, developing a unique series of symptoms. The influence is wholly toward deterioration of tissue and perversion of function, and has no application in medicine. Locally, the effects differ among the compounds mainly according to solubility. The insoluble

compounds are soothing and absorbent, like the insoluble salts of bismuth, while the soluble are decidedly astringent, but yet, in proportion to the astringency, are far less irritant than most other astringent metallic salts. The therapeutics of lead salts consist in the application of the insoluble compound (carbonate) as an absorbent and healing dusting powder, and the employment of the soluble salts as metallic astringents in catarrhs, or, in weak solution, as cooling lotions in inflammation or irritation of the skin. In these applications the following points need attention: 1. The carbonate should not be applied too extensively over a raw surface, else, through chemical conversion, enough lead may be absorbed to produce distinct constitutional lead poisoning. 2. No lead compounds should be applied to the eye, for, though excellent for simple irritation or catarrh of the conjunctiva, yet there is the peculiar danger that if a loss of the epithelium of the cornea occur, whether by ulceration or by traumatic abrasion, application of a lead solution will produce an instant, indelible, opaque, white streak over the area of exposed underlying corneal tissue. 3. Lead salts should not be given internally for longer than a very few days, lest constitutional lead poisoning result.

II. THE COMPOUNDS OF LEAD USED IN MEDICINE.—These are the *monoxide, carbonate, iodide, acetate, basic acetate, nitrate*, and *oleo-palmitate* (lead plaster).

Lead Monoxide: PbO. Lead monoxide is the compound so well known as *litharge*. It is official in the United States Pharmacopœia as *Plumbi Oxidum*, Lead Oxide. It is in the form of a heavy yellowish powder or minute scales, insoluble in water or alcohol and without smell or taste. It is not used medicinally under its own form, but is official as being the source, in pharmacy, of the solution of the lead subacetate and of lead plaster.

Lead Carbonate: $(PbCO_3)_2Pb(HO)_2$. This salt, the common *white lead* of the paint shops, is official in the United States Pharmacopœia as *Plumbi Carbonas*, Lead Carbonate. It is in the form of a heavy white powder or pulverulent mass, and, like the oxide, is insoluble in water or alcohol and is without odor or taste. As its formula shows, it is a mixture of the normal carbonate and the hydroxide. White lead is used as a dusting powder, as already set forth, or it may be applied mixed to the consistence of paint with linseed oil, or it may be used in ointment, in the shape of the official *Unguentum Plumbi Carbonatis*, Ointment of Lead Carbonate, a mixture of ten per cent. of white lead with benzoinated lard. White lead, being so largely used in the arts, is a fruitful source of lead-poisoning.

Lead Iodide: PbI_2. This compound is official in the United States Pharmacopœia as *Plumbi Iodidum*, Lead Iodide. It is in the form of a heavy yellow powder, slightly soluble in cold water and in alcohol, but more readily soluble in boiling water (1 to 200.) The claim of lead iodide to medicinal recognition is based upon the theory that the salt will yield the peculiar effects of an iodide along with those of lead. But in practice the medicine seems to amount to little else than a very slightly soluble lead salt, and is little used. It has been given internally in doses of from 0.03 to 0.20 gm. (gr. ss.–iij.). For external application there is an official *Unguentum Plumbi Iodidi*, Ointment of Lead Iodide, consisting of ten parts of the lead salt to ninety of benzoinated lard.

Lead Acetate: $Pb(C_2H_3O_2)_2 3H_2O$. Normal lead acetate, the salt well known as *sugar of lead*, is official in the United States Pharmacopœia as *Plumbi Acetas*, Lead Acetate. The salt occurs in colorless, bright prismatic crystals or scales, of a faint vinegar-like odor and a characteristic taste at first sweetish and astringent, and afterward metallic. It dissolves freely in water and fairly in alcohol (1 to 21). It effloresces and absorbs carbon dioxide from the air on exposure. The solutions commonly show a slight turbidity, which, however, is easily removed by the addition of a few drops of acetic acid. Commercial sugar of lead is apt to be contaminated with lead sulphate or carbonate, an impurity which may be suspected if a sample fail to dissolve wholly in water. The salt is decomposed by the alkalies, by acids, by soluble sulphates, chlorides, citrates, and tartrates, and by lime water.

Lead acetate is one of the most powerful of the lead salts. In rather weak solution it evinces the combined astringency and soothing influence characteristic of soluble lead compounds, but in strong solution is distinctly irritant, so that the salt is a possible severe irritant poison. Lead acetate may be used externally in solution as an astringent wash, with the caution already given about application to the eye. The strength of lead lotions commonly ranges from the one-half of one to one or two per cent. Internally the salt is a good deal given as an astringent in diarrhœas, and has also an ancient reputation of being of avail for the arrest of hemorrhage in quarters inaccessible to local measures. This alleged hæmostatic potency is held in high esteem by some, but by others is considered wholly imaginary. By the very conditions of the case this virtue is one impossible to establish or disprove by methods of precision.

Lead acetate is administered in doses of from 0.06 to 0.20 gm. (gr. i.–iij.) every two hours or so, and, when given in diarrhœa, is probably more often than not combined with an opiate.

Basic Lead Acetate: $Pb(C_2H_3O_2)_2.2PbO$. When lead monoxide (litharge) is boiled in a solution of lead acetate it dissolves with the formation of certain basic acetates, the composition of the resulting basic salt depending on the proportion of litharge to sugar of lead in the making. The United States Pharmacopœia avails itself of this reaction, and by taking the ingredients in the proportion of ten of litharge to seventeen of acetate, obtains a solution of basic acetates of which the principal one is the triplumbic acetate of the formula given above. This solution is proportioned so as to be about twenty-five per cent. strength of salts, and is officially entitled *Liquor Plumbi Subacetatis*, Solution of Lead Subacetate, called also *Goulard's Extract*. It is a clear, colorless liquid, of a sweetish, astringent taste, and an alkaline reaction. It is easily distinguishable from a solution of the normal acetate (sugar of lead) by the fact that it produces a dense, white precipitate with a solution of acacia. Solution of subacetate of lead is exceedingly easy of decomposition; even the carbon dioxide of the atmosphere will attack it and render it milky by the formation of the insoluble carbonate of lead. It must therefore be kept in well-stoppered bottles. It is decomposed also by so many other substances, organic and inorganic, that the practical rule is a good one, viz., to combine this solution, in extemporaneous prescribing, only with opiates. The following preparations of the United States Pharmacopœia are made from this solution:

Ceratum Plumbi Subacetatis, Cerate of Lead Subacetate; Goulard's Cerate. This cerate consists of twenty per cent. of the above solution mixed with camphor cerate, and is specially directed to be freshly prepared when wanted for use. This is because the preparation rapidly decomposes on keeping, turning yellow and becoming rancid.

Liquor Plumbi Subacetatis Dilutus, Dilute Solution of Lead Subacetate; Lead Water. This solution is simply three parts of the foregoing diluted with ninety-seven of distilled water, previously boiled and cooled to deprive it of free carbonic acid. Lead water is of the average strength wanted for actual application of a subacetate of lead solution, and may therefore be prescribed for use without dilution.

These two preparations, derived from the parent solution of the subacetate, are much used as gently astringent, and at the same time soothing applications to sores, excoriations, or inflamed conditions of skin. Lead water is frequently combined with laudanum for the allaying of superficial pains, such as the pain of erysipelas, of a scald, or of a sprain.

Lead Nitrate: $Pb(NO_3)_2$. The salt is official in the United States Pharmacopœia as *Plumbi Nitras*, Lead Nitrate. It occurs in octahedral crystals, either colorless and transparent or white and opaque, according to the method of preparation. The crystals are permanent in

the air, without odor but with the usual sweetish, astringent and metallic taste of the soluble lead salts. The salt dissolves in two parts of cold water and more freely in boiling water. It is almost insoluble in alcohol. Lead nitrate acts like the acetates, and is used only for external applications. A peculiar property of the salt is that it decomposes sulphuretted compounds, and thus proves deodorant to parts generating foul secretions, such as nasal surfaces in ozæna. *Ledoyen's disinfecting fluid* is a twelve and a half per cent. aqueous solution of lead nitrate. Lotions of the nitrate average two per cent. in strength.

Lead Plaster (*Diachylon Plaster*). Under the title *Emplastrum Plumbi*, Lead Plaster (Diachylon Plaster), the United States Pharmacopœia recognizes the product resulting from boiling together in a sufficiency of water thirty-two parts of lead oxide and sixty parts of olive oil. Such product, an oleo-palmitate of lead, is a fairly hard solid, of a yellowish-white color, pliable and tenacious, but not greasy. Upon keeping it turns brown on the surface. Lead plaster exerts but feebly the peculiar effects of lead compounds, though a case of lead colic has been recorded as resulting from long-continued application of the plaster as a dressing to an ulcerated surface. The main use of lead plaster is as a basis, non-specific, for medicated plasters. *Edward Curtis.*

LEAD PALSY.—Muscular paralysis resulting from the toxic effect of lead is seen most frequently among those whose occupation requires frequent or continuous contact with lead. Thus, it is commonly found in those employed in lead-works, and among painters, typesetters, file-makers, plumbers, glass grinders, and those who glaze pottery with lead, and also in other industries. The accidental causes are numerous, such as the contamination of drinking-water by leaden pipes, the cooking of food in vessels containing lead, the use of various cosmetics, hair dyes, etc. It has also been traced to snuff which was found to contain lead. As a rule, the lead enters the system by way of the alimentary canal, as a result of uncleanliness, and through the pollution of food by hands that have been in contact with lead. It may also enter the system through inhalation, and by absorption from the skin. As in other forms of toxæmia, individual susceptibility to the effect of lead has much to do with the development of lead palsy. Females suffer oftener than males, and people in general ill-health and those addicted to alcoholics seem more predisposed to its toxic action. Only a certain proportion of individuals whose occupation requires the frequent handling of lead are thus poisoned, while many similarly employed are never affected, although no special precautions are taken. After lead poisoning has existed for some time, and not necessarily manifesting any conspicuous symptoms, a peculiar form of multiple neuritis ensues. This is characterized by paralysis of several of the muscles of the upper extremities, occurring first and most pronounced in the distribution of the musculospiral nerve, affecting the extensors of the hands and fingers, but rarely involving the sensory fibres.

As a rule, other symptoms of lead poisoning—especially lead colic, acute constipation, and at times articular and muscular pains, or some of the manifestations of encephalic saturnism—precede the paralysis. It is rarely acute as a sequel of an attack of colic, but generally develops itself in the course of several weeks.

The paralysis may be the first and only recognizable symptom. These patients are frequently found anæmic, with a blue line on the gums close to the teeth, due to the deposit of lead, and signs of arterio-sclerosis or chronic nephritis may also be present. Almost always the common extensors of the fingers are first affected, especially the extensors of the third and fourth fingers; then the extensors of the wrist and little fingers follow; later, the extensors of the wrist, and ultimately the long thumb muscles. The extensors of the hand and fingers are in most cases exclusively involved. These different muscles are affected in varying degrees. The hands and fingers are held in the position of flexion, and drop as soon as they are placed in extension. On account of the lack of opposing force, the flexors are weakened in their action, but when support is given to the hand by passive extension they act normally. The paralysis of the extensor muscles of the wrist causes "wrist-drop," which produces the characteristic attitude of the hands commonly seen in these cases. In some instances the paralysis is not confined to the distribution of the musculospiral nerve, but all of the intrinsic muscles of the hand which are supplied by the ulnar and median nerves may also be involved. In the majority of cases, the triceps and supinators remain intact. It is only in the most severe forms that the latter muscles are involved. This condition is usually found associated with paralysis in the distribution of other branches of the brachial plexus and with pronounced symptoms of saturnism. Although lead has a strong predilection for the muscles already mentioned, these may escape. Lead palsy usually affects both upper extremities simultaneously, but it is not at all uncommon for it to attack only one arm. The right upper extremity is generally more paralyzed than the left in right-handed persons, and vice versa. It is quite uncommon, however, for both sides to be equally affected. Atypical cases occur in which the supinators, biceps, brachialis anticus, and deltoid are the principal muscles affected (upper arm type of Remak). To this group is generally superadded paralysis of the supra- and infraspinati. This form of paralysis is usually bilateral, and occurs in the most inveterate types of lead poisoning. When this group of muscles is affected, the patient is unable to lift his arm, and it hangs powerless by his side. Sometimes the deltoid is the only muscle involved.

The paralysis is always of a degenerative form, and is most frequently attended or followed by atrophy and loss of faradic irritability and the reaction of degeneration in the affected muscles, as a result of degeneration of the nerve fibres. Fibrillary tremor is usually present. As a rule, there is no disturbance of sensibility. In the more chronic cases there may be a slight swelling over the extensors of the wrist joint. This is due to the long-continued flexion of the carpus producing displacement backward of the bones and distention of the synovial sheaths. The lower extremities are very rarely affected. When this does take place, the muscles involved are the long extensors of the toes and the peronei muscles. The tibialis anticus usually escapes. In fatal cases, the paralysis invades the muscles of respiration, *i.e.*, the intercostals, the diaphragm, and the muscles of the larynx. In some chronic cases the symptoms may closely resemble those of bulbar paralysis.

Primary atrophy (the atrophy preceding the motor paralysis) may occur in the intrinsic muscles of the hands. It sometimes becomes permanent and progressive, just as in other forms of progressive atrophy of spinal origin. The lesion producing lead palsy usually affects the peripheral motor neurons. In chronic cases the peripheral nerves are the seat of well-marked interstitial neuritis. Changes have also been found in the cells of the anterior horns of gray matter of the spinal cord, and also in the anterior nerve roots.

Diagnosis.—In the majority of cases a correct diagnosis of lead palsy is based on the following conditions: its etiology; the peculiarity of onset and its association with other signs of lead poisoning; the characteristic degenerative type of the paralysis and its limitation to certain groups of muscles in the distribution of the musculospiral nerve, with the escape of other muscles supplied by the same nerve; and its frequent bilateral character.

Prognosis.—If there are no serious complications the prognosis as to life is favorable. When the paralysis is not extensive and is of recent occurrence, recovery usually takes place, under proper conditions. The presence of the reaction of degeneration does not militate against recovery. The voluntary power may return before faradic irritability. Recovery occurs, as a rule, when the source and continuance of the lead absorption is eliminated. On the other hand, the course of primary atro-

phy is extremely chronic, and it has little tendency to recover.

Treatment.—The treatment should consist in removal from the source of contamination by lead and its elimination from the system by the administration of small doses of iodide of potassium three times a day, and an occasional cathartic dose of sulphate of magnesia. The joints and paralyzed muscles should be supported by suitable prosthetic apparatus. The daily application of the galvanic current and gentle massage will hasten the restoration of normal function. General tonic treatment is usually indicated. *William M. Leszynsky.*

LEAD POISONING, ACUTE AND CHRONIC.—ACUTE POISONING.—Cases of acute lead poisoning are comparatively rare and are ordinarily of accidental origin. The form of lead swallowed is usually the acetate, sometimes the basic acetate in the form of Goulard's extract. It may be the ordinary white lead or other lead salts, and cases have not infrequently been reported of poisoning by the yellow lead chromate used in coloring candy. There is no danger of acute lead poisoning by lead salts prescribed medicinally, since the toxic dose is so much larger than the medicinal dose. From ʒ iv. to ʒ viij. (15.5 to 31 gm.) is, for example, the poisonous dose of lead acetate.

Symptoms.—It is a curious fact that acute lead poisoning presents, within the period of a few hours, almost the entire series of symptoms caused, in much slower stages, by chronic poisoning. Within a few minutes after swallowing a large portion of any of the soluble lead salts the patient perceives a sweetish, followed by a metallic, taste. This is quickly succeeded by a burning sensation in the throat and stomach and by nausea and vomiting. Severe colicky pains in the bowels follow, with a retracted rather than distended abdomen. There are great thirst and marked general distress and prostration, with slow pulse and cold extremities. The bowels are constipated and the urine is scanty. Sometimes there are cramps in the extremities, and it is said that even paralysis has resulted from acute poisoning. Fatal cases usually terminate in convulsions and coma, within two or three days. Recovery is, however, the rule, even after the ingestion of such a large quantity as one ounce and over of lead acetate.

Post-mortem Appearances.—These are not specially characteristic, being usually those of an acute gastro-enteritis or entero-colitis with particularly contracted small intestines.

Treatment.—If the patient is seen early the stomach should be emptied with the stomach tube or pump. In the absence of such appliances nature's efforts at evacuating the stomach should be aided by the hypodermic use of apomorphine or the internal administration of sulphate of zinc. The latter is supposed also to be of value by contributing to the formation of an insoluble lead sulphate in the stomach. Magnesium sulphate and sodium sulphate are also employed for their combined chemical and cathartic action. After these come emollient drinks and the use of opiates to relieve pain.

CHRONIC POISONING.—The introduction of small quantities of lead into the body, during a considerable period of time, brings about a peculiar disease known as lead poisoning or plumbism, accompanied by a varied train of symptoms, some of which are of brief and others of quite long duration. The methods of exposure to lead poisoning fall under two heads—first, those which may be called accidental, and to which every one may be exposed; and secondly, those which are incident to certain occupations. Under the first head comes the accidental introduction of some of the lead salts into food, as by the use of cooking utensils lined with an enamel containing lead; the use of canned goods, especially acid fruits, long canned, which may absorb lead from the solder; the drinking of beer which has stood for many hours in a lead pipe; the use of flour ground with stones the holes of which have been filled with lead, etc. The employment of lead pipes for the conduction of drinking-water has undoubtedly often caused lead poisoning. This is particularly true if the water is rain or snow water, containing no mineral ingredients. Lead-lined tanks for the holding of such water are absolutely to be interdicted. Hard waters, which contain lime and magnesium sulphates and carbonates, cause the deposit of a comparatively insoluble lead sulphate or carbonate within the pipe, thus protecting the water from contamination. Even then it is always wise, before drinking water from lead pipes, first to let that which may have stood in the pipes run to waste.

Lead suction pipes in wells are very dangerous. The best metal for this purpose is block tin.

By far the greater number of cases of lead poisoning, however, are those which are due to the inevitable exposure incident to certain occupations. Workers in lead mines and workers in lead alloys, as plumbers, lead-pipe makers, type-founders, and even typesetters, furnish frequent instances of poisoning. The same is true of those engaged in the making or handling of lead pigments.

Still more frequent are the cases occurring among those employed in the manufacture of white lead (lead carbonate), and in the honest old days, when they actually handled white lead extensively, the painters gave their name (*colica pictonum*) to one of the prominent symptoms of lead poisoning. A comparatively recent industry, which contributes a very heavy contingent to the cases of lead poisoning in this country, is the smelting and refining of the silver-bearing lead carbonate ores of this country and of Mexico. These smelters, scattered over the land from the crest of the Rocky Mountains (Leadville) to the Atlantic Ocean (Perth Amboy), employ many thousands of men among whom occur many hundreds of cases of lead poisoning annually. The considerable number of deaths and the much larger number of permanently disabled men for which this industry is responsible, and which, under proper precautions, might be avoided, is a matter that ought to be taken cognizance of by state and local health boards, wherever such smelting works exist.

Method of Introduction of the Poison.—Practically the only method by which lead is introduced into the system, among lead workers, is by means of lead-laden dust, this dust entering the nose and mouth and being conveyed to the stomach. There is no such volatilization of lead as would permit of its introduction in gaseous form, through the respiratory system, although the so-called smoke from blast-furnaces or retorts or the steam from kettles carries lead dust, just as ordinary smoke carries soot. The moustache, the fingers, and the clothing of the workman are loaded with this very fine dust, and this is not only swallowed when he opens his dinner bucket and eats with unwashed hands in the workroom, but it coats his upper mucous membranes all the time, is carried home in and disseminated from his clothing, and is present with him constantly.

Symptoms.—These may be divided as follows: 1. Lead cachexia, which often precedes more violent manifestations and generally persists through the entire history of the disease. 2. Lead colic. 3. Lead encephalopathy. 4. Lead paralysis.

Lead Cachexia.—After a variable period of exposure, sometimes extending over but two or three weeks, but oftener over from three to twelve months or even longer, the patient shows signs of failing health. He complains of a loss of appetite, of a sweetish taste in the mouth, sometimes of vomiting, especially after breakfast, always of constipation, of a general sense of lassitude, often of pains simulating rheumatism, either about the joints or in the muscles, perhaps of frequent cramps in the calves of the legs or in other muscles, very likely of vague abdominal pains. On examination he will be found to be somewhat emaciated, sallow, with a foul, coated tongue and very bad breath, the tongue not seldom betraying a tremor on being protruded. If to these signs and symptoms is added the characteristic blue line on the gum, the diagnosis is fairly assured. This blue

line, about 2 mm. wide at the junction of the gum with the teeth, occurs in a large proportion of cases of chronic lead poisoning. It is often hard to distinguish from the discoloration due to an accumulation of tartar on the teeth of people who give their teeth no care. Nor must the absence of the blue gum line be considered conclusive evidence against lead poisoning.

The symptoms above enumerated being present, it is essential that the patient be removed from the danger of further poisoning. This can sometimes be done, in a smelting or manufacturing plant, without throwing the man out of work, by giving him some different employment, out of reach of lead dust or smoke, and if possible out of doors. Moderate purgation and warm baths; if possible sunshine and good food; a little later, when the stomach is in better shape, bitter tonics with iron; and then the exhibition of iodide of potassium for a time, may bring the patient out of his cachectic condition without his developing the more violent symptoms presently to be described. The only safe course for a person who has shown well-marked symptoms of lead poisoning is to abandon the occupation which has induced the malady, but it is often impossible to bring this about.

2. *Lead Colic.*—Quite frequently persons who are attacked with lead colic have previously observed none of the symptoms above described, either because of the general stupidity of the individual or because the symptoms were truly absent. The colic comes on suddenly and soon attains great violence. It has usually been preceded by and is accompanied with obstinate constipation. The abdominal walls are rigid and sunken, there is no tenderness on pressure, and the pain is referred to the region of the umbilicus. The pain is usually continuous, with violent exacerbations every few minutes, or at longer intervals. The attack, under proper treatment, may last for two or three hours or for as many days. It rarely subsides until there has been a copious evacuation of the bowels and not always then. Retching and vomiting are not infrequent. The pulse is usually slow and hard. There is no rise of temperature.

The treatment consists in the hypodermic use of morphine, large doses, not less than half a grain, being often required, and the evacuation of the bowels. The latter may be a difficult task. It may be accomplished by repeated doses of Epsom salts or it may require the use of croton oil in doses of two or three drops. Enemata are helpful at the last. Mercurial purgatives are to be avoided on account of their possible retention, with subsequent salivation. In one instance after two or three days of colic and constipation, in spite of all cathartics, violent convulsions having supervened, the writer has seen the inhalation of chloroform promptly followed by free catharsis and recovery. A severe attack of colic is not likely to be very soon followed by another. A period of some weeks more commonly intervenes, even though the individual may still be exposed to the same malign influences as before.

3. *Lead Encephalopathy.*—By this vague term, which is practically a confession of ignorance, we refer to those graver disturbances of the nervous system, such as convulsions, mania, and coma, which sometimes follow in the wake of other and often repeated symptoms of lead poisoning and are very likely to end the life of the victim. Although, as just stated, these grave disturbances most frequently follow prolonged lead cachexia, repeated attacks of colic, lead arthralgia, and perhaps even paralysis, yet it is possible for them to be the first, as well as the last symptom of lead poisoning in a given case. This seems to be particularly true in the case of members of the negro race. The writer has repeatedly seen able-bodied negroes, in early or middle manhood, who had been working for months or years at lead furnaces, who were well nourished and had never lain off on account of sickness, suddenly fall in convulsions, which recurred frequently for a few days and were followed by coma and death. Other cases have been reported in which encephalopathy appeared as the first symptom after very brief exposure to the influence of lead. More commonly, however, it is the old lead-worker who has been through the whole list of the symptoms of plumbism, who finally develops lead eclampsia or who falls into a state of mental hebetude and apathy, gradually deepening into coma or breaking into delirium and mania. Not all of these cases prove fatal. Subjects with eclampsia may have but few seizures or may remain subject to them for years. Those with active delirium and mania frequently recover.

The treatment of these patients, during the attack, is the same as of those suffering from similar conditions not dependent on lead poisoning.

4. *Lead Paralysis.*—This subject is fully treated of under the heading *Lead Palsy*, and will therefore not be here considered.

Lead Arthralgia has not been treated of under a separate heading because it is never met with alone, but always accompanies some one of the other forms of lead poisoning. It is, however, a very troublesome accompaniment and may require for its relief the use of the salicylates, antipyrin, or similar drugs until the iodides, which are being used for the elimination of the lead, have had their effect.

Chronic nephritis is one of the terminal complications of chronic lead poisoning which should not escape the notice of the practitioner.

Pathological Anatomy.—There is very little known of the pathological changes which take place in connection with lead cachexia, colic, or encephalopathy. In death following colic the intestines have been found contracted, the muscular coat hypertrophied, and the mucous membrane more or less atrophied. This would seem only to point to nature's effort for the relief of the habitual constipation due to lead. In spite of many theories on the subject the philosophy of the poisonous action of lead on the body is as yet not understood.

Prognosis.—The prognosis as to life is good. As to recovery it is also good, except in a few extreme cases, provided the subject can be induced to withdraw himself entirely from exposure to lead. The vast majority of such persons recover entirely, lead paralysis even disappearing. Even those who do not abandon the occupation in which they have been poisoned, who have suffered from repeated attacks of colic and from paralysis, having recovered from the latter, may return to their former work and keep at it for years before being again prostrated. But sooner or later the cachexia will deepen and the victim, unless carried off by some intercurrent disease, will succumb to his old malady.

Treatment of Lead Poisoning.—The treatment has already been considered in the preceding sections, but the reason for recurring to the subject here under an independent head is to insist on the prophylaxis against the disease. In ordinary life all that is necessary is to bear in mind the possibilities of accidental poisoning and to guard against them. In carrying on industries that inevitably expose their employees to lead poisoning, proprietors should adopt all such precautions as will reduce the danger to the minimum, and it is the duty of the state, through its health authorities, to see to it that this is done. Otherwise thousands of ignorant and stupid workmen will suffer in health and become a burden to the state. Much can be done to lessen the amount of dust and smoke in workrooms and to carry it away by means of hoods over the mouths of furnaces or over work-tables, with proper suction or blast attachments. Respirators, sponges tied over the mouths of operatives, and like appliances are impracticable, interfering too much with free respiration. Supplying eating-rooms away from the dust or smoke and absolutely enforcing the rule that no man enters the eating-room without removing his hat if worn at work and outer body garment and thoroughly washing his face and hands, would do much to prevent lead poisoning. Eating in working rooms should be strictly prohibited. The drinking-water supplied to operatives should be strictly pure, and kept in closed receptacles that cannot be opened in the dust- or smoke-laden atmosphere.

Facilities for free bathing should be furnished and men should be urged to avail themselves of the same. Instruction should be given as to the precautions whereby the risk of poisoning is reduced to a minimum.

In addition to these measures a competent medical service should be inaugurated, not only for the treatment of the sick but for the inspection of the employees; and, on the recommendation of the medical man, such employees as show the early symptoms of lead poisoning should be removed from posts of danger, being either assigned to work that is not dangerous, laid off temporarily, or discharged.

As regards the medicinal treatment of lead poisoning the old methods have not been improved upon. Such laxatives as will answer the purpose must be employed; iron, quinine, and strychnine should be given in full tonic doses; and, for the elimination of the lead, iodide of sodium or potassium should be prescribed in fifteen-grain doses three times a day for two or three weeks or more at a time, to be resumed again after an intermission of a couple of weeks. Except in cases of confirmed eclampsia resembling epilepsy, some cases of paralysis, and those in which organic changes in the kidney have supervened, this line of treatment, with absence of further exposure to the poison, will usually result in a cure.

Edward W. Schauffler.

LEBANON SPRINGS.—Columbia County, New York.

Post-Office.—Lebanon Springs. Hotel.

Access.—From Bennington, Vermont, or from Chatham, New York, viâ Lebanon Springs Railroad. The location is in the extreme northeastern corner of Columbia County, 155 miles north of New York and 25 miles northeast of Chatham. This spring claims our attention as being the only thermal water in the extensive territory embraced by New York and the New England States. The temperature, 75° F., is about the same as the Old Sweet Springs of Virginia. The spring yields about 30,000 gallons hourly. The following analysis was made by Prof. H. Dussance:

Lebanon Thermal Spring.

One United States Gallon Contains:

Solids.	Grains.
Sodium carbonate	2.41
Calcium carbonate	4.04
Potassium sulphate	1.04
Magnesium sulphate	1.06
Sodium chloride	.96
Sodium sulphide	.02
Iron oxide	.94
Alumina	.45
Silica	3.25
Organic matter	10.21
Total	24.38
Gases.	**Cu. in.**
Carbonic acid	0.48
Oxygen	2.00
Nitrogen	3.52

This place has been a well-known resort since pre-Revolutionary days. The salubrity of the climate and the beauty of the scenery tend to make the surroundings very attractive. The water is used principally for bathing. A valuable chalybeate spring is located in the village of the Brickyard Shakers, a short distance from Lebanon Springs.

James K. Crook.

LECITHIN.—Lecithin is a complex phosphorized fat occurring, apparently, in all forms of protoplasm but most abundantly in the brain, spinal cord, and nerves of the higher animals and in the eggs of all animals. In the nervous tissues it is usually combined with other substances to form protagon and similar compounds. In the egg it seems to be combined with a proteid (vitellin); this combination is easily broken up by boiling with alcohol.[1] It has been found in the mucous membrane of the stomach, in the lungs, kidney, liver, spleen, semen, blood, milk, bile, pus, and serous fluids and exudates; in many cases it is combined more or less firmly with proteids to form lecithalbumins (Liebermann[2]). It is a prominent constituent of the electrical organ of the ray. It has also been obtained from the yeast and other vegetable cells.

Lecithin was first obtained in quantity by Gobley from the yelk of the egg of the fowl. It is usually prepared[3] from the hen's egg as follows. The yelk is shaken with ether until the latter is no longer colored; the insoluble residue is then extracted with alcohol at a temperature of from 50° to 60° C. The ether-alcohol extract is concentrated to a syrup at 60° C.; this is then dissolved in a small amount of absolute alcohol and the solution exposed to a temperature of about −10° C. for twelve to twenty-four hours. The lecithin separates out in the form of small round clumps. It may be purified by dissolving it in chloroform and precipitating with acetone.

Lecithin is a colorless or yellowish-white, waxy, imperfectly crystalline substance which may be kneaded but often crumbles during the process. It is very hygroscopic; upon the addition of water it swells up and forms a kind of emulsion. It is soluble in alcohol, less so in ether; it also dissolves in chloroform, benzol, and oils. On cooling a solution of lecithin in alcohol it separates in crystalline clumps. When a little lecithin under the microscope is treated with water or glycerin it is seen to swell and little curling filamentous processes protrude from the edge of the solid; these are the so-called "myeline forms" and they may simulate nerve fibres or nerve cells. When lecithin is burned it leaves a residue of metaphosphoric acid. Lecithin combines readily with acids; the hydrochloride forms a double compound with platinum and cadmium chlorides. The platinum compound, which has the formula $(C_{44}H_{90}NPO_9Cl)_2 + PtCl_4$, is insoluble in alcohol, easily soluble in water, and contains 10.2 per cent. of platinum. By removing the metal with hydrogen sulphide the lecithin may be obtained in a perfectly pure form; analysis shows it to have the formula $C_{44}H_{90}NPO_9$.

Lecithin is easily decomposed by acids and alkalies; it also undergoes decomposition when allowed to stand in contact with water. When an ethereal solution of lecithin is shaken with dilute sulphuric acid the water is found to contain the base cholin (*q. v.*), while in the ether is found distearyl-glycerin-phosphoric acid. The latter is glycerin-phosphoric acid $(C_3H_5(OH)_2OPO_3H_2)$ in which the two hydroxyl hydrogens are replaced by the radicle of stearic acid; hence its formula is $C_3H_5O_2(C_{17}H_{35}CO)_2$-$OPO_3H_2$. When lecithin is boiled with barium hydroxide, cholin, glycerin-phosphoric acid, and barium stearate are formed:

$$\underbrace{C_{44}H_{90}NPO_9}_{\text{lecithin.}} + 3H_2O = \underbrace{2C_{18}H_{36}O_2}_{\text{stearic acid}} + \underbrace{C_3H_9PO_6}_{\text{glycerin-phosphoric acid.}} + \underbrace{C_5H_{15}NO_2}_{\text{cholin.}}$$

The cholin is readily identified by the formation of a characteristic double compound with platinum chloride (see *Cholin*). These decompositions show that lecithin is a compound of cholin with distearyl-glycerin-phosphoric acid. At one time it was thought that lecithin was simply a salt in which cholin plays the part of a base, but Hundeshagen[4] prepared synthetically a cholin salt of distearyl-glycerin-phosphoric acid which was isomeric with lecithin but which did not possess the characteristic properties of lecithin. Hence lecithin is more probably an ether-like combination, the cholin being united to the acid by means of the oxygen of the hydroxyl. So far, efforts to prepare lecithin synthetically have failed.

Instead of stearic acid, palmitic or oleic acid, or both, may occur in the lecithin molecule; hence there are a number of lecithins, and the one considered above is more properly termed distearyl lecithin. In some of the lecithins of plant origin the acid radicle seems to be combined not with cholin, but with a similar base, betain; such lecithins have been found in the beet root and cotton seed. It is possible that in the brain some of the lecithin contains neurin instead of cholin.[5]

When lecithin undergoes putrefaction glycerin-phosphoric acid and cholin are formed: the latter is readily decomposed into marsh gas and trimethylamine. Under some little understood conditions a small amount of the highly poisonous base neurin is formed from cholin (and so presumably from lecithin) by the action of bacteria.[6] Apparently such a decomposition may also take place in the intestine.[7]

Lecithin is decomposed by the pancreatic juice into cholin, glycerin-phosphoric and stearic (or other fatty) acids.[8] These products are absorbed and the urine of a dog fed upon the yelk of eggs contains an increased amount of phosphoric acid. As the fatty acid is absorbed, lecithin may serve, to a limited extent, as a food.

Nothing definite is known as to the origin of lecithin or as to its use in the plant and animal economy. That it serves a very important purpose, however, is made probable by its very wide, perhaps universal, distribution in living matter. Burow [9] showed that the quantity of lecithin in the milk of an animal varies with the weight of the brain of the young of that animal. Thus, in a series of experiments the following results were obtained. Ratio of weight of brain to body weight: calf, 1:370; dog, 1:30; man, 1:7. Ratio of lecithin to proteid of milk: calf, 1:71; dog, 1:47; man, 1:33.

Attention was called above to the fact that lecithin combines with acids; thus, one molecule of lecithin combines with one molecule of carbon dioxide. The red blood corpuscles contain about 0.75 per cent. of lecithin, so that 100 gm. of red blood corpuscles might hold 22 c.c. of carbon dioxide in loose chemical combination; these facts may be shown to have a bearing upon the manner in which carbon dioxide is held combined in the blood.

Lecithin and its decomposition products have attracted some attention from the standpoint of pathology; thus, Mott and Halliburton think the cholin formed from its decomposition may account for some of the symptoms observed when there is a breaking down of nervous tissue (see *Cholin*), and Nesbitt's work suggests the possibility of poisonous effects resulting from the formation of neurin from lecithin in the intestines.

Lecithin, either in the pure form or in the yelk of eggs, has been used occasionally in therapeutics. Huchard [10] claims to have obtained good results from the administration of lecithin to patients suffering from diabetes, anæmia, tuberculosis and other wasting diseases; he thinks pure lecithin, rather than the yelk of eggs, should be employed, as the latter give rise to an increased production of uric acid.

The presence of lecithin in an organ or liquid may be detected in the following manner. An alcoholic extract is prepared; this is evaporated to almost dryness at a temperature of about 60° C., care being taken to keep the reaction of the solution neutral. The residue is then extracted with a mixture containing equal parts of alcohol and ether; this extract is evaporated to almost dryness and the residue extracted a number of times with ether. The residue, after evaporation of the ether, is fused with sodium hydrate and potassium nitrate and tested for phosphoric acid by one of the usual methods; the presence of phosphoric acid shows that lecithin was present in the original extract, for the salts of neither phosphoric nor glycerin-phosphoric acid are soluble in alcohol and ether. Another method consists in decomposing the lecithin with barium hydroxide and examining the solution for the decomposition products of lecithin, viz., cholin, glycerin-phosphoric and stearic acids. The lecithin may be determined quantitatively by determining the amount of phosphoric acid obtained on its decomposition. If the organ or tissue contains jecorin, however, the figure for lecithin will be too high, for this body (which contains phosphorus in the form of glycerin-phosphoric acid) is also extracted by alcohol and ether (see *Jecorin*).

Burow used the following method for determining the lecithin of milk. To 200 c.c. of a mixture containing equal parts of ether and alcohol and a little acetic acid, 100 c.c. of milk is added one drop at a time. After standing for fourteen hours in a well-stoppered vessel, the liquid is filtered off and evaporated to a syrup at a temperature not exceeding 50° C. The syrup is extracted several times with ether, the ether evaporated, and the phosphorus determined in the residue in the usual way.

Reid Hunt.

[1] Hoppe-Seyler: Med. Chem. Untersuch., p. 215.
[2] Liebermann: Archiv f. d. ges. Physiol., 50 and 54, p. 573.
[3] See Diakonow, Hoppe-Seyler's Med. Chem. Untersuch., p. 223.
[4] Hundeshagen: Journ. f. prakt. Chemie, n. F., 28, p. 219, 1883.
[5] Lippman: Ber. d. deutsch. chem. Gesellsch., 20, p. 3206. See also E. C. Shorey: Journ. Amer. Chem. Soc., 20, p. 113.
[6] Schmidt: Archiv d. Pharmacie, 229, p. 485.
[7] Nesbitt: Journ. of Exper. Med., 4, p. 1, 1899.
[8] Bokay: Zeit. f. physiol. Chemie, 1, p. 162.
[9] Burow: Zeit. f. physiol. Chemie, 30, p. 495.
[10] Huchard: Journ. des Praticiens, 1901, p. 439.

LEECHES. See *Hirudinea.*

LEG, APPLIED ANATOMY OF.—In anatomy the term leg is used to indicate only that part of the pelvic limb between the knee and the ankle, the portion above the knee being known as the thigh.

In man the shape of this region is somewhat characteristic. In most other animals the bellies of the great muscles are above the knee, and the leg is comparatively slender; in man, however, the erect position requires the constant application of muscular force to hold the foot at right angles to the axis of the limb, and this causes very considerable bellies to be formed below the knee. The prominence of the calf is, therefore, not only characteristic of footmen, but, to a certain extent, marks the higher races of mankind generally. Australians and other low savages resemble children and apes in the slender calibre of their legs.

It is not quite correct to compare the leg to an inverted cone, as is often done. In a fully developed man the prominence of the calf is confined mainly to the upper and posterior part of the limb, and represents the two bellies of the gastrocnemius, the inner one being larger and descending somewhat farther than the outer. This prominence is enormously developed in ballet-dancers, who possess here a dense, hard ball of muscles, quite characteristic of the occupation. It may be brought out more fully by rising upon the toes. In women the calf has usually a somewhat different shape, the muscular prominence being masked to a certain extent by fat, and descending somewhat lower than in males. The bones being more slender, the ankle is more finely modelled, and the whole contour of the limb approaches more nearly those lines of grace which please the eye in the "Greek Slave" or in Canova's "Venus." It is this contraction of the leg toward the ankle that makes it necessary to take certain precautions in bandaging, by proceeding from below upward and making the necessary reverses. It is also the reason why the circular operation for amputation is not so easily performed here as above the knee, it being difficult sufficiently to retract the "sleeve." The shape of the ankle is, however, far from being cylindrical, the strong, flat tendo Achillis producing a prominent projection behind, as will be seen on inspecting Figs. 3183 and 3186. Anteriorly, the leg is remarkable for the considerable area throughout which the bone is quite subcutaneous. The inner surface of the tibia, along its whole length from the tuberosity downward to the end of the malleolus, is but slightly covered, and in case of fracture the ends are very apt to extrude, a compound fracture being more frequent here than in any other part of the body. The anterior edge, popularly termed the shin, may be followed down as far as the lower third, where it begins to be rounded and covered with tendons passing over the ankle into the foot. The lack of soft parts here to serve as a cushion under the skin causes it to be liable to certain injuries. A blow from a blunt instrument, which would elsewhere produce a contusion, will here cause an incised wound. Contusions may also produce the same blood tumors that we see occasioned in a similar way upon the skull.

The usual curve of the crest of the tibia may be exag-

gerated by various causes. One of the earliest signs of rickets is an increase of the bend at the lower part. If children are encouraged to walk too early there is usually an outward bend, causing the child to appear bandy-legged. It is probable, however, that when this is considerable, there is a defect in the nutrition of the bones. Where the potable water shows a marked deficiency of lime salts deformities of this kind are more common. Still, it is not unusual to see the limbs of a bandy-legged child straighten as puberty approaches, and it may be questioned whether a certain degree of this defect is not due to a reversion to the type of tibia found in our "frugivorous ancestors of arboreal habits." Among negro children bandy legs are very common. As this defect occasions an unusual prominence of the shin, and con-

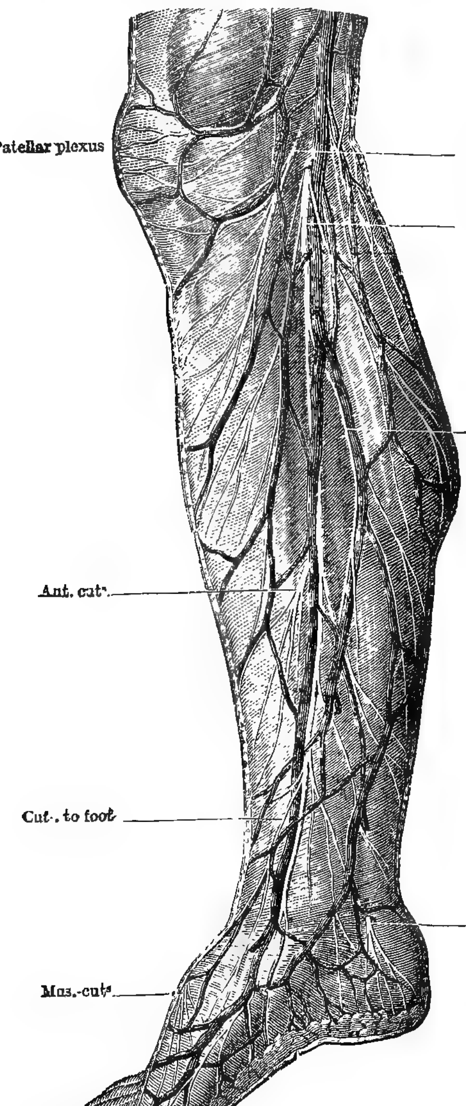

FIG. 3180.—Cutaneous Veins and Nerves of the Right Leg, Internal View.

sequent liability to injury, it is probable that there may be some slight ground for the prevalent notion that the shin of the negro is one of his most vulnerable points.

In certain races, especially those that approximate to the prehistoric type, such as the Esquimaux, the Patagonians, certain Indians, early Europeans, and the mound-builders, a peculiar form of tibia is found which

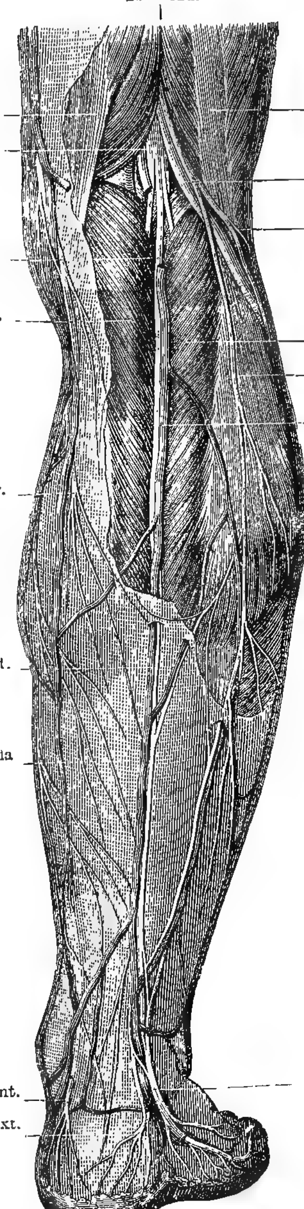

FIG. 3181.—Branches of Right External and Internal Saphenous Veins.

is decidedly simian in character. The bone is markedly flattened from side to side, and presents a sabre-like edge on the crest. This is known as the platycnemic tibia. Wyman found upon examination of a considerable number of skeletons of the mound-builders that about sixty per cent. of their tibiæ were platycnemic. It seems quite probable that, in such legs the tibialis anticus muscle is larger and more deeply embedded between the bones than is the case in the usual type, adapting the foot to strong inversion of the sole, as is the case with apes, and thus making climbing easy.

The fibula, although not so superficial as the tibia,

may be felt for a great portion of its course, especially below, where fracture is most common. The head and the external malleolus, with the triangular facet above it, are subcutaneous. The close contiguity of the skin

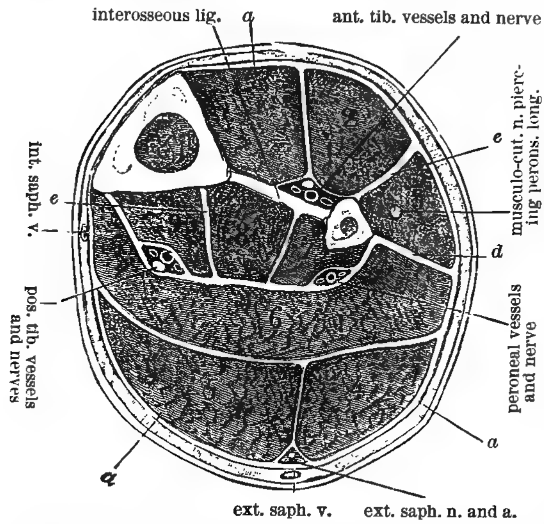

FIG. 3182.—Diagram of a Transverse Section through Right Leg, at Upper Third, to show the Disposition of the Intermuscular Septa. Lower surface of section. *a, a, a,* Deep fascia or aponeurosis; *d, e,* intermuscular septa; 1, tibialis anticus; 2, ext. long. dig.; 3, peroneus longus; 4, ext. head of gastroc.; 5, int. head of gastroc.; 6, soleus; 7, flex. long. hall.; 8, tibialis posticus; 9, flex. long. dig.

to the periosteum and bone makes it very easy for pathological processes to be continued from one to the other. It is often seen, therefore, that ulcers of the leg are followed by periostitis and necrosis of the bone.

The skin and subcutaneous tissues are not so freely supplied with arterial vessels as are the corresponding portions of the upper extremity. The superficial veins are, on the contrary, very numerous, as may be seen on an inspection of Figs. 3180 and 3181. Being far removed from the heart, acting against gravity, outside the muscles, and therefore without the assistance of muscular contraction, the circulation through them is unusually sluggish.

These peculiarities cause this region to be particularly liable to congestive disturbances and to defective nutrition. Eczema is common here; it is a favorite locality for the spots of purpura, and patches of brownish discoloration appear from the staining of the skin with the coloring matter of the blood, especially in old persons who heat the legs much before the fire. This the older physicians called *ephelis ab igne,* indicating its relation to freckles, or *ephelis a sole.* Ulcers are very common; a small abrasion, which would elsewhere heal without trouble, here remaining indefinitely, and being very difficult to cure without placing the patient for some time in a recumbent position.

The most common situation for ulcers is naturally where the bones are subcutaneous, and the leg most exposed to violence. Syphilitic ulceration is also common, especially in front of the knee.

The principal venous trunks are two. The internal saphenous vein (Fig. 3183) arises on the inner side of the foot from the inner extremity of the dorsal venous arch, courses upward in front of the internal malleolus, then behind the internal border of the tibia, and passes into the thigh behind the inner condyle of the femur. It finally discharges into the femoral vein through the saphenous opening in the fascia lata. The external saphenous vein (Fig. 3183) arises from the external end of the dorsal venous arch of the foot, passes behind the external malleolus, upward along the tendo Achillis over the gastrocnemius, and penetrates the deep fascia to empty into the popliteal vein. Both of these veins communicate frequently with the deeper veins by short branches through the fascia, and both are accompanied by cutaneous nerves.

For the reasons before mentioned these veins are very liable to become varicose, especially with those who stand much in one position, like washerwomen; and these varicosities usually occur at those points where a communication exists between the superficial and deep systems. The enlargement is frequently accompanied by considerable pain, because of the pressure upon the accompanying nerves. Varicosities are also likely to occur in those whose occupations require them to use powerfully the muscles of the leg while the thoracic and abdominal muscles are comparatively fixed, as, for instance, in pushing a heavily loaded wheelbarrow uphill. In this case the vein is constantly acted upon by the contraction of the leg muscles, which force the blood from the deep veins into the more superficial ones, and also by the weight of the superincumbent column of blood and the compression exercised upon it by the muscular action of the diaphragm and the abdominal muscles. The wearing of tight garters, or any other obstruction to the circulation such as a gravid uterus or any other abdominal tumor pressing on the main vascular trunks, is liable to occasion varices, anasarca, or some other symptom of congested circulation. It is found that the left leg is more commonly affected in this way than the right. This may be partly accounted for by the presence of the sigmoid flexure of the colon on the left side, which, containing periodically an accumulation of fæces, presses on the iliac veins.

Probably atony of the walls of the colon, with a dilatation and partial impaction of the sigmoid flexure, is less rare than is commonly supposed. It is said that cold feet have been cured by thoroughly washing out the colon, and thus modifying the circulation of the limb. But another cause for the greater frequency of affections of this kind in the left leg is the peculiar arrangement of the iliac veins. Since the vena cava is on the left side of the spine, the left common iliac has to cross to the op-

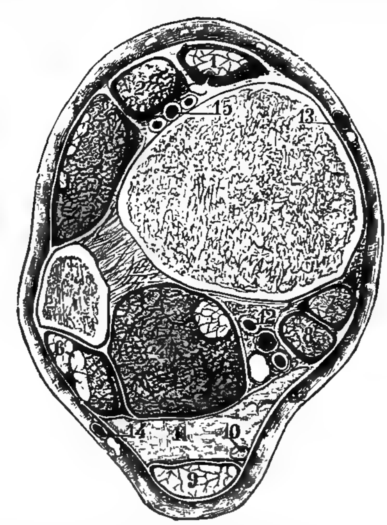

FIG. 3183.—Transverse Section of Left Leg, just above the Bases of the Malleoli. Inferior surface of section. 1, Tendon of tibialis anticus; 2, ext. prop. hall.; 3, ext. com. dig.; 4, flex. long. hall.; 5, peroneus brevis; 6, peroneus long.; 7, tibialis posticus; 8, flex. long. dig.; 9, tendo Achillis; 10, plantaris; 11, fatty tissue; 12, sheath of posterior tibialis, vessels and nerves; 13, internal saphenous vein and nerve; 14, external saphenous vein and nerve; 15, anterior tibial vessels and nerves.

posite side, and in doing so dips under the right common iliac artery, which is crossing in a similar way from the aorta to the right side. A little lower down, the iliac vein passes under the left common iliac artery. In both these cases the artery crosses nearly at right angles to the direction of the vein, and at every pulsation occa-

sions a certain amount of obstruction to the free flow of blood through the latter. On the right side the arteries which cross the veins do so obliquely, so that there is much less obstruction. Varices are not confined to the superficial veins. Verneuil thinks that they frequently occur in the venous plexus which exists between the superficial and deep muscles of the calf, and that this may explain the pain which occurs without obvious cause in those whose occupation requires them to stand a great deal. It is interesting to note that we may trace the ultimate cause of varices to the erect posture. Man is the only animal in which the weight of the whole column of blood contained in the vena cava presses directly upon the veins of the lower limbs. The cava has no valves, and, recalling the action of the hydraulic press, we see at once what a powerful effect the weight of its column of blood must have. This defect in the structure of the vascular system is explained when we remember that in other animals the vena cava is, in the ordinary posture, nearly horizontal, and the blood which it contains exerts no pressure upon the veins of the leg. The leg itself is amply provided with valves. The cessation of valves at just the point where they would be of most use is really one of the many proofs which anatomy gives that man has assumed the erect posture within so recent a period that the body is not yet perfectly adapted for it.

The fascia covering the leg is arranged as in the other limbs. A single dense layer ensheaths the whole, blending intimately with the periosteum wherever it touches the bone, and with the ligaments both above and below. Its thickness prevents abscesses from readily appearing on the surface, and pus is more apt to burrow along the intermuscular septa.

The sartorius at its insertion sends a strong aponeurotic expansion to it, so that any action of the muscle makes the fascia tense. The superficial muscles of the leg have all a considerable origin from the fascia, and this greatly increases their effectiveness. They also arise from the septa which the fascia sends down between the muscles. Of these there is one on the outer side, passing inward to the posterior border of the tibia, and one passing between the tibia and fibula, usually spoken of as the interosseous ligament (Fig. 3182). These two separate the muscles in front and externally from the posterior muscles, dividing thus the leg into two separate compartments, which are practically independent of each other, as any effusion in one never passes into the other. The muscles in the anterior compartment are so compressed by the dense tissues surrounding them that they usually bulge out through an incised wound, and when it is necessary to make in it a longitudinal incision, as, for instance, when the anterior tibial artery is tied, it is advisable to relieve the sharp tension of the edge of the fascia by a cross cut.

The anterior compartment is subdivided by a layer of fascia extending from the external sheath to the anterior border of the fibula, separating off the peroneal muscles from the remainder. The latter again are separated by a fibrous partition, which passes between the anterior tibial and the extensor communis. This well-marked fibrous septum may be used as a guide in tying the anterior tibial artery. In the lower part of the leg the extensor of the great toe and the peroneus tertius lie directly outside the tibialis anticus. The order in which the tendons pass down over the instep is shown in the article on the *Foot*.

The anterior tibial artery (Fig. 3184) is the chief object of surgical importance in the anterior compartment. It is the smaller of the two divisions of the popliteal, and attains the front of the leg by passing between the two heads of the tibialis posticus muscle, and above the interosseous ligament, which is deficient in the upper part of the tibio-fibular interspace. It is here very firmly united with the denser fibrous tissues, and when wounded it is very difficult to secure it. As it is held open by its attachments, hemorrhage is usually profuse, and it is often necessary to tie the femoral artery to control it. The general direction of the vessel is under a line drawn from the inner side of the head of the fibula to midway between the malleoli. This latter point should be estimated by standing directly in front of the foot with a finger on each malleolus. As the artery lies in the first muscular interspace which occurs on passing outward from the tibial crest, there may be a slight groove brought out directly over the course of the artery when the muscles are caused to contract by strongly bending the foot upward. At its upper portion the vessel lies deeply against the tibia and the interosseous membrane,

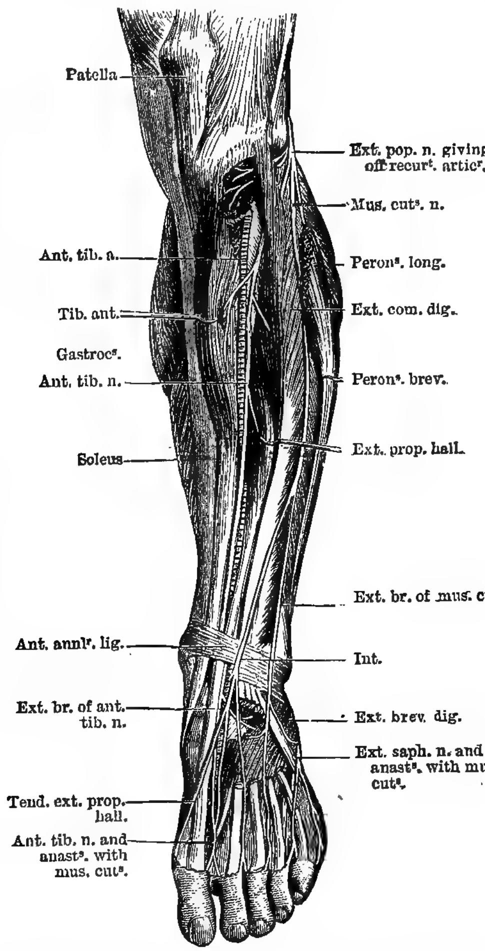

FIG. 3184.--Dissection of the Front of the Left Leg and Dorsum of Foot.

and between the tibialis anticus and the extensor communis. It is here very difficult to reach, and is not usually tied, except when wounded. In that case the usual rule is followed of enlarging the wound and securing the bleeding ends. Lower down, as the muscles become tendinous, it is more accessible and easily secured. It then lies between the tibialis anticus and the extensor proprius hallucis, the latter tendon covering it just as it passes under the annular ligament to become the dorsalis pedis. The artery is accompanied by the anterior tibial nerve, which reaches it by passing around the head of the fibula (Fig. 3185), where it is somewhat liable to injury. The nerve is, therefore, at first external to the vessel, but afterward it gets in front and occasionally crosses to the inner side. Venæ comites accompany the artery, and by their frequent anastomoses greatly increase the difficulty of securing it. It is not unusual for the artery to be wounded by splinters of bone when the tibia is fract-

tured; and the nerve may also be injured in the same manner, causing great pain, which may appear to the patient to be in the foot or ankle. Section of the nerve is not a serious matter, as it does not alter notably the functions of the member.

In the external or peroneal compartment there are but two muscles, the peroneus longus and peroneus brevis (Fig. 3185). These are long and slender, attached strongly to the fibula and to the deep fascia above, and tapering below into rounded tendons, which pass behind the external malleolus. They are supplied by the peroneal nerve, which may be injured by a fracture of the fibula, whence may result a considerable impairment of the functions of the foot, as the outward pointing of the toes is mainly accomplished by these muscles. The head of the fibula is sometimes torn off by the sudden muscular traction of the biceps muscle, and the lesion is usually accompanied by a considerable amount of pain, which may continue during the entire time that the callus is forming. This is due to the close contiguity of the peroneal (external popliteal) nerve.

The posterior compartment of the leg is by far the largest of the three. A strong intermuscular septum divides it transversely into two (Fig. 3182), separating the muscles into superficial and deep groups. The superficial muscles form a well-marked group attached to the tendo Achillis, and therefore act together as a rule. These form the prominence of the calf before mentioned, and consist of the gastrocnemius superficially, under it the soleus, which considerably exceeds it in size, and the insignificant plantaris. Many anatomists describe the gastrocnemius as two muscles, and from this conception arises the French name *les jumeaux*. Combined with the soleus the whole muscular complex is known as the triceps extensor suræ. The two heads of the gastrocnemius take origin above the condyles of the femur. It is, therefore, a muscle which controls two joints, and its contraction flexes the knee and at the same time extends the foot. When it is affected by rheumatism it may cause spurious ankylosis of the knee-joint. The coexistence of extension of the foot will enable the observer to make a diagnosis. The fibres of either head are arranged in a beautiful penniform manner around a tendon which cannot be completely displayed until the muscle is cut and turned back. Its coadjutor, the soleus, does not pass over the knee-joint, but is attached to the tibia and the fibula, throwing across between the two a fibrous arch of fascia which protects from compression the vessels as they pass under it. The gastrocnemius and the soleus are remarkably subject to cramps. This muscular affection, which appears usually to be an irregular muscular action, independent of the nervous system, may be brought about by slight causes, such as a draught of air blowing on the calves, and vigorous exercise in swimming or running, especially when cold currents are directed on the limb. The greater frequency of the disorder in these muscular masses is probably due to the peculiarities of the blood-supply to the leg, to which allusion has been made, and anything that tends to produce a more active circulation through the muscles, such as kneading or rubbing, will relieve the cramp. It is suggested that both in this case and in others in which massage upon the leg is necessary, some care be taken to apply it along the trunks of the veins and in a direction from the periphery toward the heart. Cramps of these muscles are frequent during pregnancy, and in that case may perhaps be due to pressure either upon the iliac veins or upon the nerve trunks in the pelvic cavity.

The little plantaris (Fig. 3187) is a vestigial muscle, representing a much larger one found in other animals. Its muscular portion is frequently not more than an inch long. It arises above the outer condyle of the femur, and terminates in a slender, threadlike tendon, which passes down along the internal border of the tendo Achillis, and is finally inserted with it into the posterior border of the calcaneum. It is probably of no impor-

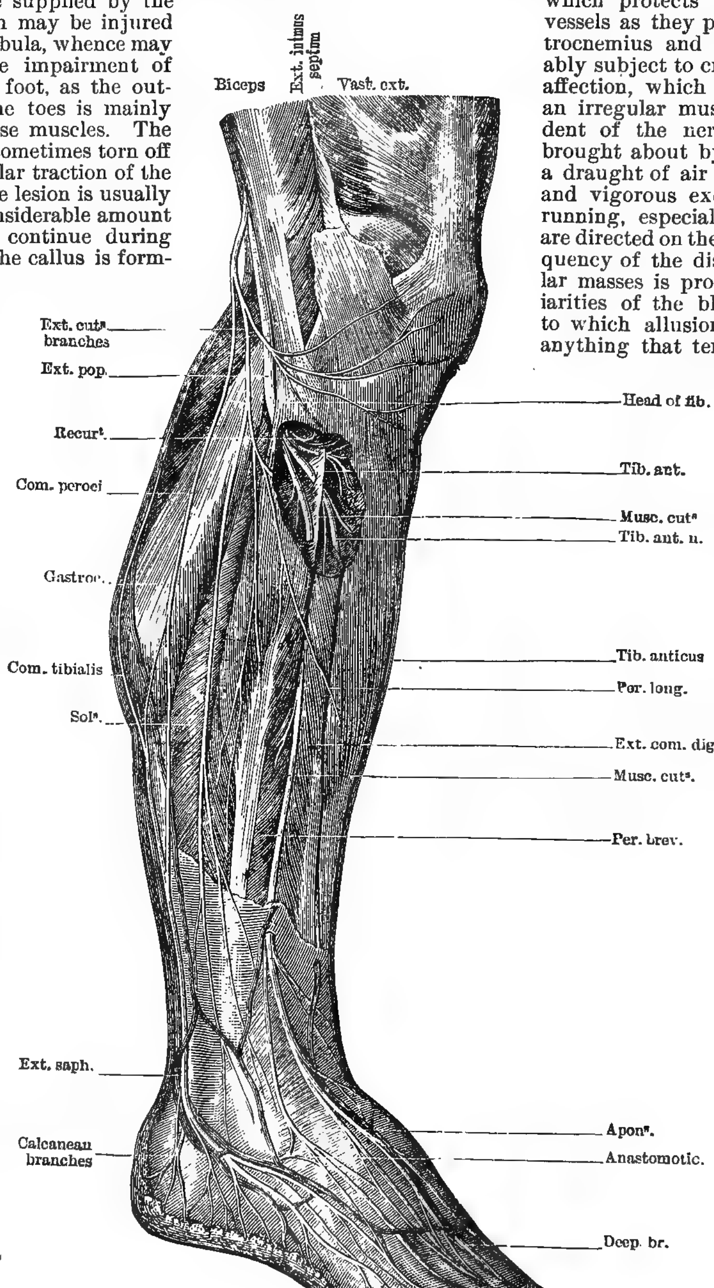

FIG. 3185.—Dissection of Outer Side of Right Leg and Foot, showing branches of Right External Popliteal Nerve.

tance whatever, though the French surgeons have imagined that its tendon may be ruptured by a sudden action,

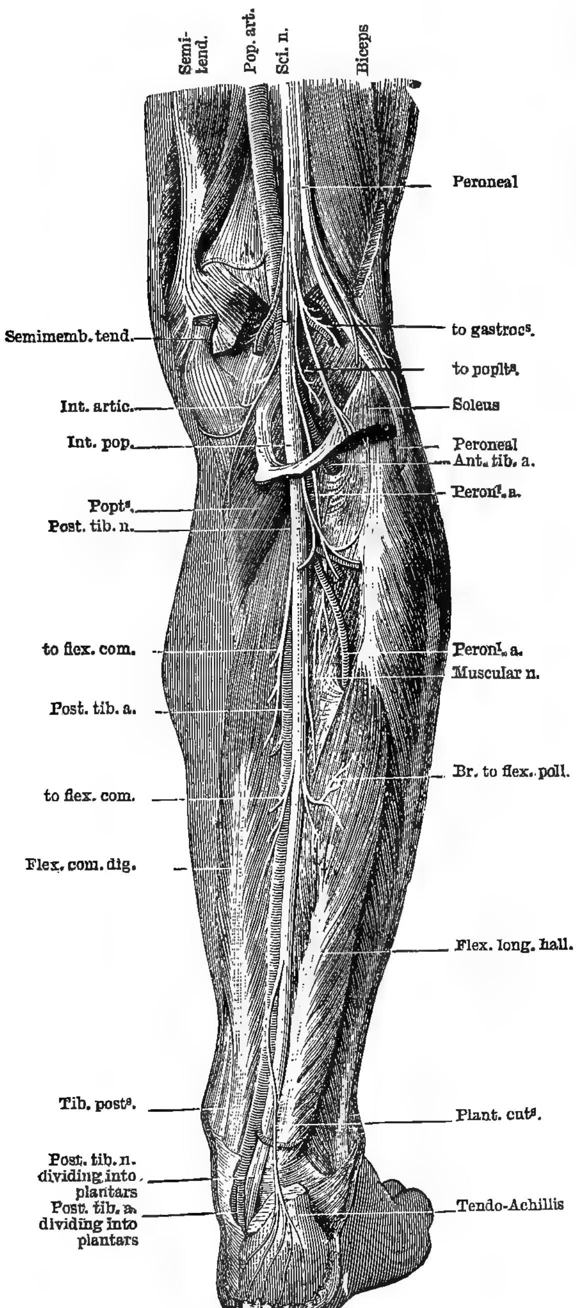

FIG. 3186.—Right Posterior Tibial Nerve and Artery. The internal popliteal nerve is seen passing beneath the fibrous arch of the soleus.

producing the affection known as *coup de fouet*—a sudden stinging pain in the calf. This affection is not rare. In a case within the writer's knowledge it occurred to a lady while dancing. It is more likely that there is a rupture in the large muscular mass of the gastrocnemius and the nerves of supply. It is not clear that the little tendon of the plantaris would cause any pain if it were to rupture, and the lesion has never been demonstrated clinically, so far as the writer is aware.

The tendo Achillis passes down to be inserted upon the tuberosity of the calcaneum. The projection which this makes behind the malleoli determines the length of that arm of the lever. In negroes and others with flat feet this projection is somewhat greater. By this setting back of the tendon two fossæ are formed, one on either side, behind the malleoli (Fig. 3183).

Between the triceps suræ and the deeper layer are the principal vessels and nerves. The posterior tibial artery (Fig. 3186) is the direct continuation of the popliteal, and receives its name on passing under the fibrous arch of the soleus. It almost immediately gives off the anterior tibial and the peroneal arteries, the rule being, according to Holden, that in amputations one inch below the head of the fibula one artery is divided, two inches two arteries, three inches three arteries. It bifurcates into the plantar arteries at a line drawn from the point of the malleolus to the middle of the heel (Wyeth). If we take a point midway on this line, and draw another line upward through the centre of the calf, we shall have approximately the course of the artery. In the upper part of its course it is so deeply buried under muscular masses that

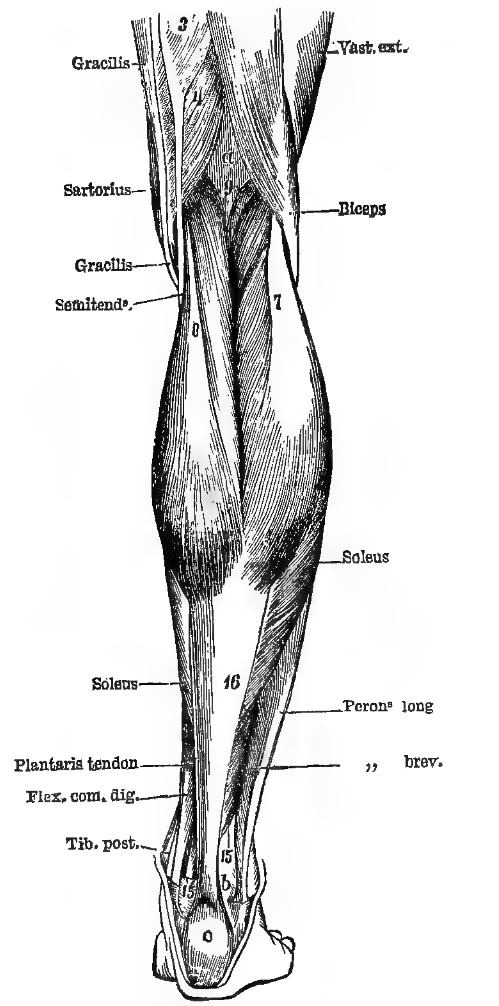

FIG. 3187.—Superficial Muscles of Back of Right Leg. *a*, Popliteal space; *b*, extl. malleolus; *c*, os calcis; 3, semitends.; 4, semimembs.; 7, 8, gastrocs.; 9, plantaris; 15, 15, flex. long. hall.; 16, tendo Achillis.

it is very difficult to reach. On this account it is usual in ligating it not to make the incision directly over the artery, but to avoid cutting the gastrocnemius by com-

mencing only two finger-breadths from the internal edge of the tibia, finding the edge of the gastrocnemius, and pushing it aside. The fibres of the soleus are then carefully divided in the direction of the artery. There is usually a deep aponeurotic tendon inclosed within the fibres of the soleus, having muscular fibres inserted on its anterior and posterior surfaces. When this is reached it serves as a warning to the operator that the artery is not far off. By separating the edges of the incision the vessel may be found, even if not exactly in the direction of the cut. It is very rarely tied here.

Below, where the artery becomes more superficial, there is no difficulty in finding it. In operating anywhere on the inner side of the leg the internal saphenous vein must be avoided. The artery is accompanied throughout by two veins, with frequent cross anastomoses, and by the posterior tibial nerve, which is at first on its inner side, but crosses over to the outer side, below where the peroneal artery is given off. A section of the nerve paralyzes the plantar muscles.

The deep layer of muscles is constituted by the tibialis posticus, the flexor communis, the flexor longus hallucis, and the popliteus. The latter muscle is confined to the upper part of the leg, arising by a rounded tendon from the groove above the external condyle of the femur, and passing obliquely inward to the tibia. It is believed to represent the pronator radii teres of the arm, and, like that muscle, assists in rotating the segment and in bending the joint. All the other muscles terminate in tendons which pass down behind the inner malleolus into the foot. Besides a considerable origin from the intermuscular septum, the tibialis posticus and flexor communis arise from the tibia; the flexor longus hallucis from the fibula. As the tendons pass downward those of the flexor communis and the tibialis posticus twist around each other, interchanging places, so that at the ankle the latter is nearest the bone. (See article *Foot.*)

Within the fibres of the flexor longus hallucis the peroneal artery runs close to the fibula, and is therefore often wounded when that bone is fractured. The artery may be of larger size than the posterior tibial, and may take the place of the anterior tibial. At its upper part it is so surrounded by fibrous structures that aneurism of it is extremely rare. It is also so well protected by the fibula that it is rarely wounded. It is still more difficult to reach for ligation than the posterior tibial, and this is not practically done except as a surgical curiosity. When effected, it is by detaching the fibular origin of the soleus and raising the flexor longus hallucis.

Frank Baker.

LEGUMINOSÆ.—(*The Bean Family*). As here considered, this family includes the three sub-families *Papilionaceæ*, *Cæsalpiniaceæ*, and *Mimosaceæ*, regarded by many botanists, and probably correctly, as distinct families. It comprises nearly 450 genera and about 6,000 species, distributed through all except very cold regions and exceedingly numerous and abundant in most tropical districts. When its general structure, chemistry, physiology, and adaptability to environment are considered, it appears to stand at the head of the vegetable kingdom. Its economic importance is of the greatest. It contributes some of the most highly prized and durable timbers, especially for cabinet purposes. Many species are so rich in tannin as to be valuable tanning agents and very many of its dye-stuffs, like logwood and indigo, have been utilized. Acacia, Senegal, Mesquit, and Tragacanth gums are elsewhere described in this work. Peanut oil is the type of a number of useful fixed oils. Tonka is a valuable perfuming and flavoring agent. Tamarinds, ingas, and other fleshy fruits are important edible products. Most of the richly albuminous fodders, like clover, alfalfa, lupines, and vetches, are yielded by this family, especially by the first-named sub-family, while peas, beans, lentils, peanuts, soja and fenugreek, in the same group, are equally important as albuminous human foods. Medicinally, the Calabar bean, senna, broom, liquorice, jequirity, araroba, Jamaica dogwood, balsams of Peru and tolu, copaiba and erythrophlœum are mere illustrations of a vast number, especially of local employment. *Ononis spinosa* L. and other species of Ononis, household diuretics, and Monssena (*Albizzia anthelmintica* [Baill.] Courd.), an anthelmintic bark treated in the preceding edition of this work, may also be mentioned.

Poisonous species are very numerous. Many of the poisonous constituents are glucosides or alkaloids, readily isolated, their activities not at all uniform. In other cases, as of abrus and locust, they are albuminoids, very difficult of isolation. In some noted cases, as that of the loco-weed, they are absolutely elusive. Even in such edible seeds as the pea and the bean there exists some unknown principle which renders them injurious when used to excess, and which causes inflammations and loss of the cutaneous appendages, even of the hoofs. This effect is very noticeable in the case of Leucæna and results in a well-marked deformity in the horse, the "cigar-tail," characterized by the complete loss of the hair of the tail. This family is capable of further very extensive exploitation in the interest of materia medica.

Henry H. Rusby.

LEMON.—(See also CITRUS). The lemon is a large, evergreen, fragrant shrub or small tree, two or three metres or more in height, with numerous straggling grayish branches and green or reddish spiny twigs. The scattering leaves are, like those of the orange, articulated to the petiole; they are ovate, rather narrow, pointed, slightly serrate, the petioles not at all, or very narrowly, winged. The deliciously sweet flowers have the same structure as those of the orange, but are rose-colored or purplish externally. The juice of the lemon, as commonly known, is excessively sour, but there are numerous varieties which are deliciously sweet. The peel and its volatile oil and the juice are official. The former, for medicinal use, is pared off with a knife in thin ribbons, so as to include but little more than the oleiferous zone. It has a fragrant, pleasant odor, and a bitterish, aromatic taste. Lemon juice is prepared by simple expression of the pulp, and straining if there are any evident shreds of the pulp or partitions in it, as these will make it bitter upon standing. It is a slightly turbid, yellow, nearly odorless, pleasantly but intensely acid liquid, of spec. grav. about 1.030. Besides these, which are prepared extemporaneously from commercial lemons, the oil of lemon (*Oleum Limonis*, U. S. P., B. P., etc.), imported from the south of Europe, is also in extensive use as an elegant and popular flavor. This oil, like that of orange peel, is to be obtained from the fresh peel by expression.

COMPOSITION.—Lemons contain three distinct leading constituents, in as many distinct anatomical parts of the fruit: The *essential oil*, in a zone of large spherical glands situated just beneath the outer surface of the peel. It should not be distilled, but separated from the rinds by the same processes as are used for the oils of orange and bergamot—that is, by in some way rupturing the vesicles and collecting it mechanically. It is a pale-yellow, fragrant liquid, of an aromatic, bitterish taste and a neutral reaction; soluble in two parts of common alcohol, and in one or two thousand parts of water. It keeps badly, becoming thicker by age, and acquiring a disagreeable turpentine-like odor. The white spongy part of the peel and the partitions have a bitterish taste, due to the crystalline neutral substance *hesperidin*, common also to the other fruits of the genus. It is not used in medicine. The pulp owes its acidity to five or six per cent. of, mostly free, *citric acid* (of which lemons, limes, and sour oranges are the principal sources), and to a little *malic acid.*

USES.—Lemons are mostly used as an agreeable and wholesome flavor for food and drink. Their medicinal value is slight, and consists in their antiscorbutic quality, for which the juice (or lime juice) is carried on shipboard, and, on long voyages, is meted out to sailors and passengers. The introduction, however, of steam navigation,

by making voyages short, and of canned meats and vegetables for ocean use, has nearly obliterated scurvy. As a grateful refrigerant drink in fevers, and especially in rheumatism, lemonade has no equal. The oil has the properties of the aromatic oils in general, but is used only as a flavor.

Administration.—The following preparations (not including citric acid or the citrates) are official: Spirit of Lemon (*Spiritus Limonis*, U. S. P., the Essence of Lemon of the kitchen) contains six parts of oil of lemon, four of lemon peel, and enough alcohol to make a hundred; macerate and filter. The Syrup of Lemon (*Syrupus Limonis*, U. S. P.) is made of: lemon juice, 40 parts; fresh lemon peel, 2 parts; sugar, 60 parts; and water enough to make 100 parts. Boil the juice, add the peel, and, when cold, filter, adding water enough to make 40 parts; finally put in and dissolve the sugar. The Syrup of Citric Acid (*Syrupus Acidi Citrici*, U. S. P.) keeps better and is almost invariably substituted for this by the apothecaries. It contains: Citric acid, 8 parts; water, 8 parts; spirit of lemon, 4 parts; syrup, 980 parts; and is a close imitation of the other. The mixture of citrate of potassium (neutral mixture, *Mistura Potassii Citratis*, U. S. P., an old fever mixture not much used at present) is lemon juice neutralized by bicarbonate of potash. Lemon juice is frequently added to the alkaline carbonates to form an effervescing draught.

W. P. Bolles.

LEMON GRASS. See *Andropogon.*

LEMON SPRINGS.—Moore County, North Carolina.

Post-Office.—Lemon Springs.

Access.—Viâ Seaboard Air Line Railroad to Lemon Springs Station, thence a little over two miles to springs. These springs are named for the former owner, the late Dr. M. Lemon. They are located in a fine, healthy region, about 500 feet above the sea level. The hotel was destroyed by fire a few years since, and the resort is suffering from undue neglect. It is said that the place could be made one of great attractiveness, both for summer and for winter visitors. The waters of Spring No. 1 were analyzed by Professor Ledoux, at that time the State chemist, who detected salts of iron, aluminium, magnesium, and other ingredients in nearly the same proportion as exist in the Buffalo lithia waters of Virginia.

James K. Crook.

LENIGALLOL—pyrogallol tri-acetate—is a white crystalline powder, insoluble in water and claimed to be non-poisonous. In contact with inflamed skin it slowly liberates pyrogallic acid, and where the epidermis is lost the change is quite rapid. It is not affected by the healthy skin, nor does it stain the clothing. With zinc ointment it tends to produce a dark coloration from slight decomposition. Kromayer recommends it in chronic eczema, at first applying lenigallol 20 parts and zinc ointment 80 parts, and later, if necessary, lenigallol 10 and oil of cade 5, or lenigallol 10, oil of cade 10, precipitated sulphur 20, green soap 5, and zinc ointment 150. Rau uses it in chronic eczema after thorough washing with potash soap. He found it useless in acute eczema. Good results are reported in psoriasis and other skin diseases. It is claimed to be unirritating even in fifty-per-cent. ointment.

W. A. Bastedo.

LENIROBIN—the tetra-acetate of chrysarobin—is considered by Kromayer a fair and unirritating substitute for chrysarobin in the milder types of skin disease. Rau uses it in ten-per-cent. chloroform solution or with traumaticin, reporting two cures of keratosis and eighteen of chronic tylosis. It is painful to rhagades.

W. A. Bastedo.

LENTIGO.—(Synonyms: Freckles, Ephelis, Ephelid; Fr., *Taches de rousseur;* Sp., *Pecas.*)

Lentigo is usually described as an eruption of multiple circumscribed, irregular, flat spots, varying in size from a pin point to that of a lentil, in color running from light greenish-yellow to dark brown or blackish, appearing on that part of the cutaneous surface most exposed to the inclemencies of the weather; the variety that appears on the non-exposed surface is commonly termed "cold freckle." As a rule the lesions are discrete, but sometimes they are so numerous and close together that they seem to run into each other and thus form a patch. Anatomically freckles, according to Cohn, consist of a circumscribed accumulation of pigment in the basal layer of cells of the rete Malpighi and in the papillary layer of the skin.

Etiology.—We may say that as a rule every one is subject to freckles, but the brunette type is unquestionably less so than the blonde, and those with so-called red hair and delicate skins are the ones most prone to suffer from this disfigurement; nevertheless I have frequently seen mulattoes of both sexes whose faces were literally covered with freckles. At the same time I have observed that the proneness to freckles in the offspring seems to increase in proportion as the white race preponderates in the ancestry of the hybrid. Some families seem more liable to freckle than others, although the exposure to sun, moisture, sea air, etc., may have been the same for all the cases. While it is true, therefore, that the chemically active rays of the sun are the most potent factor in producing this disfigurement, we must conclude that there are other factors whose nature is at present unknown to us. These factors are those responsible for freckles appearing on the least exposed portions of the body, as the buttocks, thighs, genital organs, etc., and for those appearing in people who are practically never exposed to inclemencies of weather.

Varieties.—To the practitioner, the most interesting form of freckle is the one that he is most liable to be called upon to treat, namely, the variety termed lentigo æstivale, or summer freckle. This is the eruption that appears on the faces of city-bred women and children of fair, tender skin, during the summer months, while temporarily residing at the seashore or in the country. Happily, this is the form that is most liable to yield to treatment, and it also has a tendency to disappear spontaneously during the winter months.

The other kind, which we may call true lentigo, is far more difficult to deal with. It may be a racial or family characteristic. This variety appears about the seventh year, persists throughout young adult life, and begins to fade about the thirtieth year. Another variety, one that has a tendency to appear in old age, may be regarded as one of the manifestations of senile atrophy of the skin.

Symptoms.—The eruption of freckles is not accompanied by any subjective or objective symptoms other than the appearance of the lesions. The various symptoms recorded by certain writers as observed in a few cases are in my opinion to be regarded as mere coincidences.

Diagnosis of lentigo is easy, if the situation and shape of the lesions and the history of the case are borne in mind.

Prognosis.—As to the summer variety this is very good, for the lesions tend to fade away during the winter, but they will reappear as soon as the patient is again subjected to the original cause that produced them.

Treatment.—From the above it will be seen that the treatment of this trouble is sometimes very satisfactory, while again it may be quite the reverse. Almost all treatment is directed, or has been directed thus far, to a destruction of the epithelium. Among the means directed to this end may be mentioned lotions and salves containing corrosive sublimate or oil of cade; the application of pure carbolic acid to each individual freckle, and electrolysis. Unna employs with good results preparations containing hydrogen peroxide and oxychloride of bismuth. As a prophylactic measure women should wear heavy red or light brown veils while at the seashore.

N. J. Ponce de Léon.

LEPROSY.—(Synonyms: Gr., λέπρα (from root meaning scaly); Lat., *lepra* (in classical Lat., *lepræ*), *elephantiasis Græcorum, satyriasis, leontiasis, lepra Arabum;* Fr., *lèpre;* Ital., *lebbra;* Ger., *Aussatz;* Norweg., *spedalskhed.*

DEFINITION.—Leprosy is a chronic, contagious, and infectious disease, produced by the bacillus lepræ; characterized by the formation of new growths in the skin, peripheral nerves, and internal viscera, producing various deformities and mutilations of the human economy, and usually ending fatally.

SYMPTOMS.—Clinically, leprosy occurs in two quite distinct forms. These were termed by Danielssen and Boeck[1] the "nodular" and the "anæsthetic." The terms "lepra tuberosa" and "lepra maculo-anæsthetica," as adopted by Hansen and Looft,[2] seem more acceptable, as they more nearly express the condition. While, as a rule, each affection runs its special course and is marked by symptoms so entirely different from those belonging to the other as to appear as a distinct disease, yet some cases exhibit symptoms which are common to both forms, and in these the relationship is evident. They have a common etiological factor, the bacillus lepræ, which, however, is in a different anatomical location, and varies as to numbers in the two forms. As in the case of other contagious and infectious diseases, the clinical history may be divided into stages.

FIG. 3188.—Tubercular Leprosy. (Dr. James Nevins Hyde's photograph of a Leper in the Sandwich Islands.)

The *period of incubation* has been carefully studied by competent observers, and cannot be said to have a definite length. It is estimated to extend over a period of from a few weeks to many years. Before the eruptive and characteristic stage develops, various prodromal symptoms such as might precede any infectious disease occur. Among these may be mentioned fever, chilliness, malaise, headache, mental depression, drowsiness, pains in the limbs, and various anomalies of the motor and sensory apparatus, especially in the limbs. Those preceding the maculo-anæsthetic form are more variable, and are chiefly symptoms which naturally arise from nerve involvement, such as pruritus, formication, pain, hyperæsthesia, etc. These may be slight or very severe, and may last for only a few weeks or perhaps for many years.

Lepra Tuberosa.—In the skin this type of leprosy appears first as a macular eruption, of varying persistence, which may come and go, but in which finally the skin becomes infiltrated with characteristic tubercles. Their commonest location is on the forehead, cheeks, nose, chin, and ears, the forearms and the thighs. Unna[3] says that the lobe of the ear is a favorite and early site. The macules are well defined, and are round, oval, or irregular in shape; in size they range from 1 to 10 cm. or more in diameter. Their color, depending on the race of the patient and the age of the lesion, varies from a light-red to a purplish or bronze shade. They may appear slightly elevated or infiltrated, or quite smooth and shiny, and somewhat hyperæsthetic. Sooner or later these patches become permanent and infiltrated with tubercles which are pea-sized, yellowish or reddish-brown, and which enlarge more or less rapidly, some of them becoming as large as a walnut or larger. The development of these is not limited to the site of the macules, for some appear on apparently normal skin, and their efflorescence is preceded by febrile symptoms, more or less severe; nor do they appear simultaneously, but rather in successive groups, each new efflorescence being preceded by febrile symptoms, and perhaps epistaxis. Although the eruption may occur on any part of the cutaneous surface, it is uncommon on the palms and soles, and is rarely found on the scalp and glans penis. In typical cases of tubercular leprosy, the face presents a characteristic appearance, so much so that the disease has been termed "leontiasis" (or lion-face) from the fancied resemblance which the distorted features suggest. The eyebrows are practically always the seat of nodules in greater or less abundance. The brow appears thickened, and when the nodules are well formed the hairs are lost. The facial appearance of a leper who has the tubercular form of the disease, is well described by Thin,[4] as follows: "The thickened skin of the forehead, studded with unequal tubercular masses, and marked horizontal furrows; the tumid, greasy cheeks, uneven with tubercles; the everted lips; the nose thickened, widened, flattened, and crushed like a negro's; and the projecting nodular ears, present an appearance which distinguishes leprosy from all other diseases, and which requires to be seen once to be always recognized." At times, by confluence of individual tubercles, large plaques are formed. (*Lépromes en nappe*, Leloir, which are dark in color and which desquamate slightly.) They are inert, lasting sometimes for years unchanged. They may be the seat of pruritus, or the sensation may become less acute; the hair falls in the involved regions and they may finally ulcerate. These large plaques usually occur on the limbs and, according to Danielssen and Boeck,[1] indicate an unusually chronic case. The tubercles may undergo ulceration, and discharge a yellowish-brown, viscid fluid, which may form crusts. Some of these ul-

cers soon heal, especially under appropriate treatment, while others extend deeply, becoming gangrenous and destroying much tissue. Bones are laid bare; tendons, ligaments, joints, and even whole members, such as fingers and toes, are destroyed. Usually at this extreme stage symptoms of the maculo-anæsthetic type are also present. During the course of the disease, the glands of the axilla, groin, neck, and throat become enlarged. In the latter situation, this adenopathy may interfere with breathing and swallowing. Eventually, the glands soften and break down, forming fistulous tracts discharging large quantities of material. At times, without apparent reason, the disease remains stationary for long periods, then suffers an exacerbation. Intercurrent diseases, such as variola, pleurisy, and pneumonia, may cause it to disappear temporarily.

Lepra occurring in children retards the physical growth and the development of the sexual organs, arresting the functions of the latter. Menstruation may be delayed or entirely inhibited. When the disease occurs after puberty, the menopause may be prematurely brought about, and the procreative faculty lessened or lost. Bracken,[10] in a report of cases in Minnesota, states that twenty-one out of thirty-four patients were married, to twenty of whom seventy-eight children were born. Alopecia, especially of the eyebrows and eyelashes, usually occurs, but the scalp is rarely attacked. Occasionally the nutrition of the nails is disturbed, as evidenced by thinning, thickening, or other deformity. The secretions of the sebaceous and coil glands are early increased, but later diminished or entirely lost in the affected area. Comparatively early in the disease, small, flattish tubercles form on the conjunctiva and cornea, extending to and involving the iris, and gradually filling the anterior chamber. The eyeball swells and the lids cannot be closed. There is pain, and the lachrymal secretion is increased. Later, the mass softens and contracts, the secretion lessens, pain stops, and the lids can again be closed (Danielssen and Boeck[1]). Other and more chronic processes occur in the eye during the course of the disease. According to Hillis,[5] throat symptoms occur during the febrile attack. The same author states further that patches having raised crescentic edges, situated at the back of the pharynx and on the roof of the mouth, the back of the throat and the uvula, which are uniformly red and congested, are pathognomonic of leprosy. Later, the epiglottis, vocal cords, and other structures in the larynx become studded with tubercles, as does also the nasal septum; and when ulceration occurs the cartilage and bony framework of the nose are destroyed, producing the characteristic deformity. Morrow believes that the earliest manifestations of leprosy in most cases are located in the mucous membrane of the pharynx and upper air passages, as shown by alteration in the voice, rhinitis, increased nasal and salivary secretions, and sometimes epistaxis.

Danielssen and Boeck[1] have described an acute form of leprosy similar to acute tuberculosis. It is manifested by a continuous fever of about twelve days' duration, when, with a sudden efflorescence, raised, shiny, bluish spots appear over nearly the whole body. These rapidly increase in volume and hardness, become confluent, and progress as far in a few weeks as does the ordinary form in years. With the appearance of the eruption, the constitutional symptoms abate, and after the tubercles have softened the affection becomes chronic. In any case in which the cutaneous exanthem fails to appear, the patient usually dies of pneumonia, pleurisy, or meningitis in the course of a few days.

The physical condition which is the ultimate lot of the unfortunate victim of tubercular leprosy cannot be equalled in any other disease. Leloir[6] graphically describes it thus: "If the patient does not die of some intermittent disease or special complication, the unhappy leper becomes a terrible object to look upon. His deformed, leonine face is covered with tubercles, ulcers, cicatrices, and crusts. His sunken, disfigured nose is reduced to a stump. His respiration is wheezing and difficult. A sanious, stinking fluid, which thickens into crusts, pours from his nostrils. The nasal mucous membrane is completely covered with ulcerations. A part of the cartilaginous and bony framework is carious. The mouth, throat, and larynx are mutilated, deformed, and covered with ulcerated tubercles. The patient breathes with the greatest difficulty, and is threatened with frequent fits of suffocation, which interrupt his sleep. He has lost his voice; his eyes are destroyed; and not only his sight, but his senses of smell and taste have completely gone. Of the five senses, hearing alone is usually preserved. Owing to the thickened and pachydermic state of the skin of the limbs, which gives to them the appearance of elephantiasis, and to the presence of ulcerating tubercles, crusts, and cicatrices, the sense of touch is abolished. Usually at this time the peripheral nerves are involved, so that the symptoms of both the tuberous and the anæsthetic type of leprosy are present. The patient suffers excruciating pains in the limbs, and even in the face, while the ravages of the disease in his legs render walking difficult and even impossible. From fistulous openings in the hypertrophied inguinal and cervical glands pus flows abundantly. In certain cases the abdomen is increased in size on account of involvement of the liver, spleen, and mesenteric glands. With these visceral lesions, the appetite is irregular or lost. There are pains in the stomach, diarrhœa, bronchial and pulmonary lesions, intermittent febrile attacks, and a hectic state. The peculiar smell, recalling that of the dissecting-room, mixed with the odor of goose's feathers or of a fresh corpse, was recognized but badly described by authors in the Middle Ages, who compared it to that of a male goat. This is the complexus of symptoms which the patient presents, unless some fatal complication has come to his relief. In this light one can understand how, in the ancient poem of Job, leprosy is called 'the eldest daughter of Death.' Nevertheless, in spite of his condition, the unhappy leper, although in great prostration, commonly preserves his intelligence unaffected to the end. I have been struck," continues Leloir, "with the calm stoicism with which the Norwegian lepers supported their misfortune, and with the indifference or even gayety of the lepers in Italy and other countries, and with the care which they gave to their toilet. I have never seen a leper ask for death, and I do not know of an instance of suicide among these patients, who observe with the greatest resignation the slow and progressive decomposition of their bodies."

Lepra Maculo-anæsthetica.—In this variety, the bacilli are located chiefly in the neuroglia of the peripheral nerves, and consequently the symptoms exhibited in the part supplied by the affected nerves are those which would naturally follow their irritation, compression, or degeneration. Chief among these are the development of spots or macules, bullæ, muscular atrophy, anæsthesia, motor paralysis, and finally mutilation by loss of parts. There is no regular sequence observed in the evolution of these symptoms. Usually, however, the maculæ and bullæ are among the earliest manifestations, but their appearance may be delayed for years.

The course of this form of the disease is exceedingly chronic, its average duration being estimated at about eighteen years. The appearance of the spots is usually preceded by anomalies of sensation, such as formication, a sensation of burning or stinging, or pruritus. The size of the lesions varies from that of a fifty-cent piece to that of the palm or larger. By peripheral extension and coalescence, large, irregular areas, having a curved contour, may be produced. At first they are reddish in color, changing with age to yellowish or brown, or even darker shades, when they tend to become slightly elevated and to desquamate. Their centres become depigmented and anæsthetic, while the border may be hyperpigmented and hyperæsthetic. Their commonest seats are usually considered to be the back, shoulders, face, arms (especially about the elbows), the nates, and around the knees. When the spots are fully developed, they may cover very large areas of the body surface. In the anæsthetic portion, and at times extending beyond it, the production of

sweat is entirely suppressed, and the hairs become white. At this stage the disease may remain apparently quiescent for a long period of time, the only symptom indicative of interference with the general health being neuralgic pains. Danielssen, quoted by Thin, states that he has seen spots remain unchanged for from eighteen to twenty years, during which time the patient suffered so little that he required no medical attendance. He adds that he has seen the anæsthetic spots on mucous membranes accompanied by redness and thickening, which disappeared without ulceration. The formation of bullæ is characteristic of this form of leprosy. They may be the initial symptom, in which case they are usually smaller and more numerous than in other affections, and are either hyperæsthetic or are normally sensitive. The older are often single, large, and may be anæsthetic. They appear suddenly, and, if short-lived (which is the rule), have serous contents, the latter becoming purulent when the lesions persist. They heal after rupture, leaving a pale scar, or, by infection, develop into deep-seated ulcers. When the nerve trunks are the seat of severe neuritis, they become much thickened, and can be readily felt by the finger of the examiner. The fusiform enlargement of the ulnar nerve behind the olecranon process at the elbow is characteristic. Other nerves especially involved may be the tibial, peroneal, and, less often, the radial, median, brachial, and cervical. Atrophic changes are noticed first in the interosseous muscles of the hands, the thenar and hypothenar being the next involved; and the atrophy extends thence up to, and involving, the muscles of the forearm. In a lesser degree, the same process occurs in the lower extremities. This atrophy in the hands produces the "lepra claw," in which the proximal phalanges are extended, while the middle and distal are more or less flexed. All the muscles of the face may atrophy, leaving it expressionless. By paralysis, the face may be drawn to one side; the lower lip, by involvement of the orbicularis oris muscle, may droop so as to make it difficult to close the mouth, thus allowing the saliva to flow over the chin. By the involvement of the orbicularis palpebrarum muscle, the lower eyelid may droop, making the closure of the eye impossible, thus rendering it liable to external injury, which produces at times ulceration and destruction of the globe. The perforating ulcer of the foot which often appears in people who go barefooted, is a trophic affection, aided in its development by pressure, and is usually located under the heel or ball of the foot. It may be deep and lead to necrosis of the bone, and is exceedingly difficult to heal. The phalanges of the feet and hands are attacked with necrosis, and complete exfoliation of the bones occurs. The fingers and toes may thus disappear, leaving only small, soft processes, upon which a sort of nail remains, to identify the member. Hansen and Looft[2] regard this necrosis as being largely due to external injury to a part of low vitality. To this stage of the disease "lepra mutilans" was the term formerly applied. Owing to a lack of unguent from its glands, the skin becomes dry, fissured, and the seat of ulceration.

FIG. 3189.—Anæsthetic Leprosy with Mutilating Results. (Dr. James Nevins Hyde's photograph of a Leper in the Sandwich Islands.)

Several constitutional symptoms which are not primarily leprous often occur in the course of the disease. These are mainly gastro-intestinal disturbances. The kidneys are liable to amyloid degeneration, which is one of the common causes of death. Finally, in time the disease may become arrested and only its sequelæ remain, such as anæsthesia, paralyzed and atrophic muscles, and mutilated members, these patients attaining a good age.

From the foregoing description of the clinical course, with its subjective symptoms and objective lesions, it will be seen that typical cases in the two forms are very different; but there are many cases which present appearances that are puzzling even to the most experienced. In a certain percentage of cases the bacilli find favorable soil for development, either simultaneously or successively, both in the peripheral nerves and in the skin, in which case symptoms peculiar to both forms of leprosy are present. Occasionally, in the tuberous variety, the nodules disappear, and the case apparently becomes the milder or maculo-anæsthetic form. The reverse also is true, though much more rarely. As to deciding any case to be a "mixed" one, Hansen and Looft[2] say: "But since every case of nodular leprosy is accompanied by affection of the nerves and anæsthesia, and the natural termination of every case of nodular leprosy is to pass into the anæsthetic form, if only, as occasionally happens, the patient live long enough; and since the skin eruptions of the maculo-anæsthetic form are characterized, just as are those of the nodular form, by the presence of the leprosy bacillus, we regard the transformation of a case of maculo-anæsthetic into nodular leprosy only as a sign of the unity of the two forms, and we delete altogether the name of mixed leprosy; otherwise every case of nodular leprosy must, in all events, after some years of existence, properly be called mixed, for in such case anæsthesia is never absent." In the Berlin Conference, in 1897, Hansen[7] described a case which presented symptoms typical of both varieties. There were red tubercles in both eyebrows and on both cheeks. These were rather soft, and had the appearance of leprous tubercles, except that no hairs had fallen out of the brows, and some hairs were even situated on the tubercles. A cover-glass examination revealed no bacilli. In 1898 he excised a tubercle, made sections, and found the usual histological structure of lepra, but only a few bacilli. At this time anæsthetic spots appeared on the arms, and there was some anæsthesia in the hands. The firstma croscopic diagnosis was tuber-

cular leprosy. Later, he considered it to be of the maculo-anæsthetic type. Some time later, he again saw the case, at which time the tubercle-like spots were transformed into true nodules, hard and devoid of hairs. Although he was now more inclined to consider it as belonging to the maculo-anæsthetic type on account of the spots and anæsthesia, yet the other appearances left the case doubtful in his mind.

History.—It is probable that leprosy has existed among the Jews from the earliest date of which we have record until the present time, and that they acquired the disease during their residence in Egypt. Kaposi believed that the leprosy of the Old Testament was merely vitiligo. Undoubtedly, many cases of vitiligo were then considered leprosy, but the cases in which ulceration (raw flesh) occurred evidently were not vitiligo. Job's affliction is considered by Thin and others to have been leprosy. Aristotle, 345 B.C., refers to a disease which he calls "satyria," and from his description Danielssen and Boeck think he must have referred to tubercular leprosy, and that his observations were made on the coast of Asia Minor. The best early clinical description of the disease was given by Aretæus in the first century of the Christian era. Celsus (53 B.C.–7 A.D.) states that leprosy was almost unknown in Italy; yet it seems probable that about this time it was introduced into Italy and spread from there into Northern and Western Europe. From the second to the seventh century it was prevalent in Europe. Galen, in the second century, writes of it in France, Germany, and Spain. In the eleventh and twelfth centuries it spread all over Europe, and in 1229 nineteen thousand leproseries existed, there being two thousand in France alone. It was unknown in America until after the arrival of the negroes from West Africa. In the fourteenth century it began to decline, and by the seventeenth it remained in only a few isolated localities. Early in the sixteenth century it had nearly disappeared from Italy, and somewhat later from France. At this time Denmark was also free. It remained in Scotland for some time after leaving England, the last cases occurring in Shetland, in the latter part of the eighteenth century. It persisted in Sweden until the end of the eighteenth century, while in Norway many cases still exist. During the last century it made its appearance and spread in new localities. About the middle of the century it was introduced into the Hawaiian Islands, where a serious epidemic has prevailed. Morrow[8] affirms that here, as in other newly infected districts, the disease was at first quickly fatal, and was usually of the tubercular variety; but of late years it has been less serious, and the milder or maculo-anæsthetic type is the more prevalent. In Louisiana, leprosy has been known since 1785, and has of late years increased, becoming endemic there about 1866.

Etiology.—It is now conceded practically by all observers that leprosy is a parasitic disease, and produced by the bacillus lepræ. Although attempts to reproduce the disease in the lower animals with this bacillus have thus far been unsuccessful, it can be positively affirmed that the bacillus is the active factor in the production of the disease. In ancient and mediæval times, and even up to a quite recent date, leprosy was considered contagious, but in 1867 the Royal College of Physicians declared against this theory. Hansen and Looft[2] quote statistics and give undeniable proof of the contagiousness of the disease in Norway. Thin[4] quotes quite a large number of cases in which leprosy was undoubtedly contracted by contagion. Among other examples, Morrow[8] quotes the case of Father Damien, a priest, whose personal and family history bore no taint of previous disease, but who, after close contact with lepers in the Hawaiian Islands, in a leper settlement, contracted the disease. Its development in new countries, or in new localities in the same country, can usually be traced and proven to have been produced by contagion. The contagiousness is not marked, and it requires the closest relationship between the healthy and the leprous before the disease can be contracted. It is not directly transmissible. Both ancient and modern writers until quite recently have considered it an hereditary disease; but the mere fact of its existence for a long period of time, perhaps for several generations, in the same family, would not demonstrate this to be the case, especially if one accepts the undoubted fact that it is contagious. The Lepra Commission in India, in 1893, reported that leprosy in India cannot be considered an hereditary disease, and stated that the evidence which exists is hardly sufficient to establish, to an appreciable degree, an hereditary predisposition to the disease in the offspring of leprous patients. Besnier[9] says that if any hereditary predisposition exists in lepra, it is less than that in tuberculosis. He suggests early and repeated bacteriological examination of the nose and pharynx, as these may be affected before the disease becomes obvious elsewhere. He explains the long incubation period by saying that the bacilli lie dormant, unable for the time being to germinate on account of bad soil. As to the mode of transmission from one person to another, different opinions prevail. Thin[4] says that close personal contact is usually necessary, but that the possibility of the infection being carried by an intermediate host, such as the mosquito or the acarus, is not impossible. Hansen and Looft[2] quote cases in which the infection was carried by way of clothing. Morrow[8] believes that in the majority of cases the contagion finds entrance to the body through the mucous membranes of the respiratory and gastro-intestinal tracts. As predisposing causes, bad hygiene, dirt, filth, and careless habits undoubtedly play an important rôle. Among the Norwegian peasants, where the disease prevails, Leloir, quoted by Thin, says that the greater number of these people have never bathed. Their clothing, generally made of wool, is never taken off, even for sleeping, and as it is never washed dirt naturally accumulates upon it; and, when not too worn, it is handed down from generation to generation. As a rule, several people sleep in the same bed; all eat at the same table, from the same dish, often from a common spoon, and drink from the same vessel. Hansen confirms the above, and states further that, under the civilizing influences of life in the United States, these habits are dropped, with the result that the disease no longer continues to be propagated, but dies with the death of those already infected. Neisser says that the number of lepers in any community bears an inverse ratio to the care taken to insure the isolation of infected persons. Leprosy may occur at any age, seldom before the fifth year, and most often between the thirtieth and fiftieth years. Damp cold climates, as well as moist hot ones, are most favorable for its development.

Geography.—The geographical distribution of leprosy is quite extensive, covering probably one-quarter of the globe. It occurs endemically in Northern and Eastern Africa, Egypt, Arabia, Persia, China, Japan, and India; Russia, Norway, Sweden, Italy, Greece, France, and Spain; the islands of the Pacific and Indian Oceans; it is prevalent in Central and South America, Mexico, the West Indies, Australia, the Hawaiian Islands, and New Zealand; and it is found in New Brunswick and other parts of Canada. It is also pretty well distributed in the United States, the most important centres being in Louisiana, California, and Minnesota. According to a report sent to the Senate on March 24th, 1902, and made by a commission of medical officers of the Marine Hospital service, leprosy is distributed as follows in the United States: Alabama, 1; California, 24; Florida, 24; Georgia, 1; Illinois, 5; Iowa, 1; Louisiana, 155; Maryland, 1; Massachusetts, 2; Minnesota, 20; Mississippi, 5; Missouri, 5; Montana, 1; Nevada, 1; New York, 7; North Dakota, 16; Oregon, 1; Pennsylvania, 1; South Dakota, 1; Texas, 3; and Wisconsin, 3; making a total of 278 cases.

Pathology.—Histologically, leprosy belongs to the group of granulomata, along with syphilis, tuberculosis, and certain other affections. It is a neoplasm, made up largely of partially reverted connective-tissue cells. In this new growth the specific bacillus is present in extraordinarily large numbers. This organism presents a

striking resemblance to the bacillus of tuberculosis, both morphologically and as regards its staining reactions. It was discovered by Hansen in 1874, and his observations were independently confirmed by Neisser in 1879. It is somewhat thinner but a little longer than the tubercle bacillus, though variations in size occur. Its average length is from 5 to 6 μ. Often in ordinary sections one finds the whole area crowded with bacilli. They frequently present a beaded appearance, which has led some observers to believe that they exhibit spore formation; this, however, is doubtful. They appear to be in groups, these usually being situated in large ovoid cells, which constitute the lepra cell. In the discharges from ulcers and diseased tissues, large numbers of bacilli are present, and the same tendency to grouping in ovoid masses is often noticeable. Besides the two common locations, the skin and the peripheral nerves, these organisms have been found in greater or less abundance in the mucous membranes, cartilages, spleen, liver, lymphatic glands, hair follicles, cornea, testicle, spermatic cords, ovaries, blood-vessel walls, kidneys, and mammary gland. They are not found in the muscles, spinal cord, bones, or joints, nor in secondary lesions, such as bullæ; nor are they found in the urine or menstrual discharges, and they are absent from all physiological secretions unless pathologically contaminated. In the skin the bacilli are found in great numbers in the tuberous variety, while in the macules of the maculo-anæsthetic variety they are present in very small numbers; but they are numerous in the connective-tissue sheaths of the peripheral nerves. Successful inoculations of the lower animals have not been made, nor has any one been able to grow the organism on artificial media outside of the human body. Campana (Rome) claims to have done so in stab cultures on glucose agar, but his observations have not been confirmed.

In consequence of the poor supply of blood-vessels in the leprous infiltrations, the nodules have low vitality and little power of organization, and therefore undergo absorptive and retrogressive changes slowly. As in the other granulomata, the principal changes are found in the corium, the process beginning about the vessels, glands, and follicles. There is cellular infiltration in, and hyperplasia of, the external and middle coats of the vessels, which by pressure narrow the lumen. The infiltration extends from these points upward to the epidermis and downward to the subcutaneous tissue. This infiltrate may be nodular or diffuse, and is composed of plasma cells, connective-tissue cells, occasional giant cells, and the lepra cells which are characteristic of this disease. These are large, ovoid cells, containing several clumps of bacilli, held together by mucoid material. Early in the process, the glands and follicles of the skin become infiltrated, and hyperplasia of the cells occurs. This is followed by degeneration and complete destruction and disappearance of these structures. The epidermal changes are purely secondary, and may consist, early in the process, in hypertrophy of the rete by pressure and irritation from below, which is followed later by atrophy; and when ulceration takes place complete destruction occurs. All throughout this infiltration, the bacilli are very numerous, and, although they are chiefly located within the lepra cell, some undoubtedly are intercellular in situation.

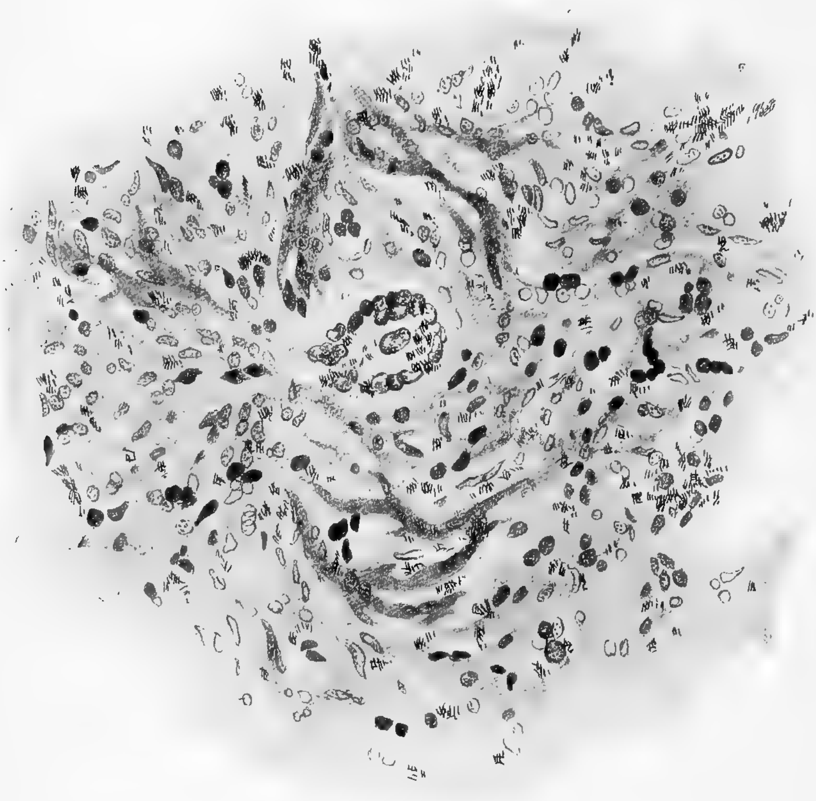

FIG. 3190.—Section of Leprous Nodule in Skin showing Lepra Bacilli and Giant Cell. (After Dom. Sauton.)

In the maculo-anæsthetic variety, nodules of proliferative connective tissue, containing bacilli, are present in the peripheral nerve sheaths, which by pressure early produce the pain and hyperæsthesia; later, as pressure increases, degeneration occurs and anæsthesia results. As some fibres escape the pressure, there are, in the anæsthetic spots, limited areas which still retain sensation. Woit,[11] whose sections and observations were confirmed by Schultz of Bonn and Strümpel of Erlangen, found that the skin filaments of the peripheral nerves were degenerated, while those supplying the muscles showed little or no degenerative changes; that ascending trophic degeneration of the sensory nerve branches was present; that the degenerative processes involving the nerves spread over the periphery; and that a central origin could be excluded. In the spinal cord, slight degeneration of the posterior columns was observed, but bacilli were never found. He believes with others that in the macules of true maculo-anæsthetic leprosy, either very few or no bacilli are present. Darier[12] says that all macules have a similar histological structure, and that they all contain bacilli, and are of the same nature as the nodules.

DIAGNOSIS.—In well-advanced and typical cases of either variety, the diagnosis of leprosy is not difficult, but in the early manifestations, especially of the maculo-

anæsthetic variety, its recognition is attended with the greatest difficulty, and numerous errors in diagnosis are recorded. In its prodromal stage, leprosy would probably never be suspected, unless it occurred in leprous districts, or there was a history of exposure to one affected with the disease. It is chiefly to be differentiated from other members of the group of infectious granulomata, especially from syphilis and tuberculosis. In any doubtful case, the demonstration of the bacillus settles the diagnosis. Many of the individual lesions of the above disorders, if taken alone, could hardly be identified as belonging to the one or the other; but if the general picture, as well as the individual lesions, be taken into consideration, the difference between the diseases becomes apparent. Both the early and the late manifestations of syphilis might be mistaken for leprosy, but the early macular syphiloderm following a demonstrable initial sclerosis, accompanied by alopecia in the scalp and throat symptoms, should be readily recognized. The eruption is of shorter duration; the maculæ are smaller, less highly colored, and chiefly located on the trunk. The maculæ of tubercular leprosy are found on the face. There is no alopecia of the scalp, but the hair of the eyebrows falls. Further, the maculæ are larger, they may be diffuse and infiltrated, and are more persistent. The tubercular syphiloderm has a tendency to remain localized in certain regions, and breaks down and ulcerates in a much shorter period. The tubercles of leprosy are larger, brownish-yellow in color, and present a shiny appearance, as if oiled or varnished. This latter characteristic is never found in syphilis. The syphilitic ulcer progresses more rapidly, and possesses a serpiginous tendency not found in the leprous ulcer. The bullæ of leprosy are not found in acquired syphilis.

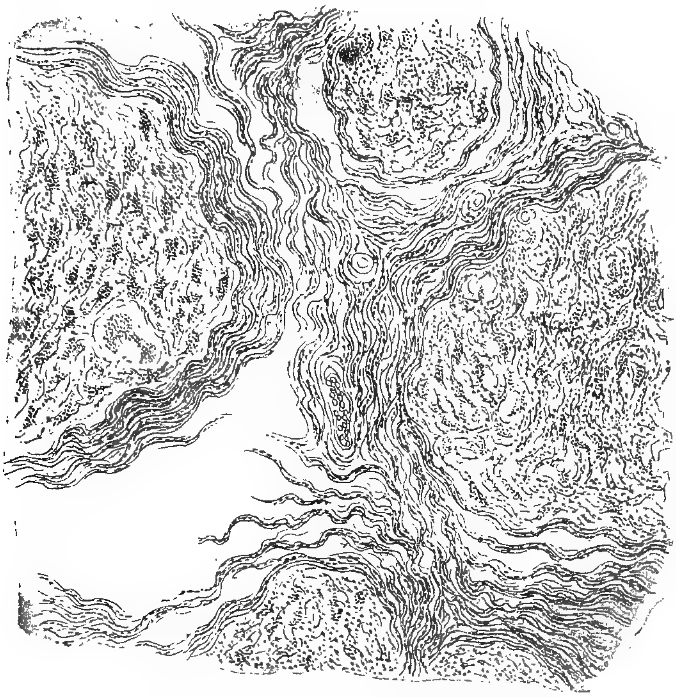

FIG. 3191.—Section of Nerve showing Lepra Bacilli. (After Jeanselme.)

Leprosy is to be distinguished from lupus vulgaris by the fact that the nodules in the latter disease occur in more circumscribed areas, and the individual lesions are smaller and unaccompanied by anæsthesia. The anæsthesia, hyperæsthesia, and constitutional disturbances of leprosy are not found in vitiligo and morphœa. Leprosy is differentiated from pemphigus vulgaris by the presence, in the former, of anæsthesia in the spots, by the limited number of the bullæ, and by the characteristic cicatrices. The presence of anæsthesia and hyperplasia distinguishes lepra from erythema multiforme.

In its later stages, anæsthetic leprosy may be confounded with syringomyelia. Hansen and Looft, in differentiating between these two, lay great stress on the fact that in leprosy a skin eruption is always present; or if not present at the same time, at least some evidence of its former existence will still be present.

PROGNOSIS.—The future of the unfortunate victim of leprosy is as dark to-day (so far as hope of complete eradication of his disease is concerned) as it has been during the many ages of its existence. Except in rare instances, the malady eventually ends fatally. Under favorable conditions, however, the disease, especially in the milder form, may cause the patient very little suffering for many years; and, were it not for the knowledge which he possesses, he might live in comparative comfort. Complete change of climate often arrests the progress of the disease for some time; but after a longer or shorter period it again becomes active. The tubercular form is much more rapidly fatal. In every country where leprosy is endemic, a few cases of apparent recovery are reported by competent authorities. These patients have complete cessation of symptoms and remain well until death ensues from other causes. Recovery may occur at any stage. Usually, however, it is in the advanced stages, after much mutilation has taken place. After a cure has occurred, Hansen and Looft[2] say: "We have occasionally a complete subject, with vigor and good health; but usually only a miserable rudiment of a human being, with more or less paralyzed hands and feet; with unclosable eyes, of which

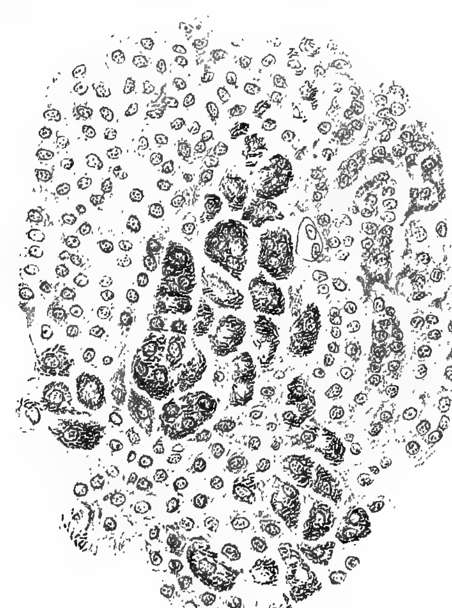

FIG. 3192.—Section of Leprous Spleen showing Lepra Bacilli. (After Jeanselme.)

the lower part of the cornea is opaque, and from which the tears roll down upon the cheeks; with paralyzed facial muscles, unable to close the mouth, so that the sa-

liva constantly dribbles from it. Such patients, however, may live long and reach great age, if under such circumstances this can be looked upon as an advantage. They die usually of some intercurrent disease."

Treatment.—During the long period of time which has elapsed since leprosy began making history, almost innumerable products and methods of treatment have been used for its relief or cure. Perhaps the most popular and largely used drug is chaulmoogra oil. This was introduced by Le Page, of Calcutta, and is used both externally and internally. Its dose is from five to seventy-five drops, three times a day, in capsules, emulsion, or milk. When the stomach will not tolerate the drug (which unfortunately often happens), Vidal recommends its active principle, gynocardic acid, in the form of gynocardate of sodium or magnesium, in capsules containing from 0.2–0.32 (gr. iij.–v.), from ten to twenty capsules being taken daily. Externally, it may be combined with olive oil, in the proportion of one part to from five to fifteen. When administered hypodermatically, it has proved irritating. Under its prolonged application, it is affirmed that ulcers heal, and the general nutrition improves, the patients gaining in weight, the anæsthesia and hyperæsthesia being corrected; the tubercles undergoing involution, and general marked improvement taking place.

In South America and China, Hoang-nan is largely used with success. It is given in pill form, in doses of three grains three times daily. Arsenious acid, creosote, carbolic acid, chlorate of potassium, formalin, thyroid extract, salol, mercury, and sodium salicylate have all been largely used. Crocker has obtained good results by the intramuscular injection of perchloride of mercury, one-quarter of a grain twice weekly.

Dyer,[13] of New Orleans, obtained marked improvement in four out of five cases by using hypodermatic injections of Calmette's antevenene. From one to eleven cubic centimetres were first injected every other day; later, the injections were repeated daily, the sites being the gluteal and intrascapular regions. When the remedy was injected into nodules these disappeared. One of the patients was apparently cured. Serum-therapy has not been successful, nor has the injection of tuberculin produced any good effects.

Unna says that both the cutaneous and the nerve lesions are benefited by the use of reducing agents, such as chrysarobin, pyrogallol, resorcin, and ichthyol. He affirms that the action of these remedies is both local and constitutional, chiefly the former, and that under their influence marked improvement occurs. Electricity is advised for the relief of pain, anæsthesia, and hyperæsthesia. Surgical measures are indicated in the treatment of tubercles, ulcers, bone necrosis, and gangrene. The condition of leprosy does not contraindicate any surgical operations which become necessary. Amputations, nerve-stretching, tracheotomy, and other operations are often demanded.

Prophylaxis.—As leprosy is unquestionably contagious, the subject of the protection of the uninfected is important. In America attention was first directed to this by Dr. James C. White, of Boston. A number of years later he again called attention to and urged measures to check the evil. The importance of this subject was emphasized again, in 1894, by Dr. James Nevins Hyde, in his report "On the Distribution of Leprosy in North America," which was presented to the Congress of Physicians and Surgeons. Still more recently, Morrow[14] has sounded a warning of the possible introduction of leprosy into the United States from her newly acquired leprous colonies. Laws at present exist prohibiting the importation of known lepers. Experience teaches, however, that this disease, which may be for years slow and insidious in its development, readily evades ordinary inspection. That great care should be taken to guard against the admission of it is shown by the fact that practically all the cases in the United States, except those in Louisiana, have been imported. Many plans for isolating these patients have been suggested and tried in various places, even to compulsory detention. The latter has been very successful in Bombay and other places. The adoption of such measures in this country is at present out of the question. Numbers of the milder anæsthetic patients, being but slightly infectious, cannot justly be confined for life; while others suffering from the tuberous variety, whose ulcers and mucous discharges are highly infective, certainly should be isolated. Important measures in the care of leprous patients concern their hygienic surroundings. A wholesome diet, warm clothing, protection from sudden changes of temperature, open-air exercise, baths, daily inunctions, and massage are all advised. That hygiene plays an important rôle in the management of leprosy is well illustrated by the immediate cessation in the spread of the disease, and by the great improvement in the individual cases themselves, among the Norwegian lepers in Minnesota. *Oliver S. Ormsby.*

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LEPTANDRA.—*Culver's Root. Culver's Physic.* The rhizome and roots of *Leptandra virginica* (L.) Nutt. (fam. *Scrophulariaceæ*). (The name *Leptandra* will doubtless replace that of "Veronica" of the present U. S. P. definition.) Leptandra grows very abundantly in rich open woodlands and copses through the Eastern and Central United States. It is a perennial herb, with simple, perfectly straight, erect, slender stems, from two to six feet high, whorled lanceolate leaves, and terminal panicles of long, slender, acute, white or pinkish, densely flowered spikes. The drug is gray-brown or gray-black, from four to six inches long, much branched and crooked, the rhizomes slightly flattened, about one-fourth inch thick. The internodes are characteristically narrowed downward and readily disarticulate. The roots are rather few, coarse, and unbranched. The drug has little odor, but a bitter, resinous, and slightly acrid taste.

The demand for Leptandra is chiefly American. It has, however, been recognized in the Pharmacopœia since its first edition and has of late increased greatly in favor, both here and abroad.

Its important constituent is six per cent. of an irritant resin, of the same general character as those of mandrake and jalap. It contains a little saponin, tannin and gum, and the peculiar bitter crystalline glucoside *leptandrin*, which is soluble in both water and alcohol, and which must not be mistaken for the commercial article so-called.

Our knowledge of the action of leptandra is purely clinical. It is a stimulating laxative or an irritant cathartic, according to its condition and dose. In the recent state it is drastic and even emetic, and poisonous, becoming milder with drying and keeping. It stimulates the intestinal mucous secretion and the dejection of bile, and also the intestinal movements, and is an excellent laxative in doses of 1 gm., and a purgative in doses of 2 to 4 gm. The long list of therapeutic properties attributed to it by the eclectics are not to be denied, but are the result of improved elimination and nutrition. The official preparations are the fluid extract, dose 1 to 4 c.c. (fl. ʒ ¼–i.) and the extract, dose 0.06 to 0.2 gm. (gr. i.–iij.).

Each official vegetable cathartic pill contains 0.0015 gm. of this extract. Commercial "leptandrin" is the practical equivalent of this extract. *Henry H. Rusby.*

LESLIE WELL.—Ingham County, Michigan.

Post-Office.—Leslie.

Access.—From Jackson, viâ the Jackson, Lansing and Saginaw Railroad to Leslie, fifteen miles north. This is a very good calcic water, with sufficient iron to give it tonic properties. Analysis by Prof. R. C. Kedzie:

One United States Gallon Contains:

Solids.	Grains.
Sodium bicarbonate	5.27
Potassium bicarbonate	4.55
Calcium bicarbonate	30.62
Magnesium bicarbonate	10.53
Iron bicarbonate	2.27
Calcium sulphate	7.04
Alumina	2.08
Silica	.65
Total	63.01

Carbonic acid gas, 13.05 cubic inches.

This water is very useful in anæmia and debilitated states of the system, especially in those affected with gastric and intestinal disorders. *James K. Crook.*

LEUCOCYTOSIS.—By leucocytosis is meant an increase of the number of leucocytes in the circulatory blood above that which is normal for the individual. This increase must affect chiefly the polynuclear leucocytes—or each variety in such a way that the relative proportions of the different leucocytes remain the same as in health.

Normal Percentage of Each Variety in the Adult.

(a)	Small lymphocytes	20 to 30 per cent.
	Large lymphocytes	4 to 8 "
(b)	Poly(morpho)nuclear neutrophiles	62 to 70 "
(c)	Eosinophiles	$\frac{1}{2}$ to 4 "
(d)	Mast cells	$\frac{1}{10}$ to $\frac{1}{2}$ "

Myelocytes represent a pathological variety of leucocytes—hence an increase of leucocytes involving especially the myelocytes is not considered a leucocytosis, but represents a special blood disease which is considered under the heading *Leukæmia.*

Again, an increase of leucocytes involving especially the lymphocytes is not a leucocytosis—but is either a lymphocytosis or a lymphatic leukæmia.

Some authorities prefer the terms hyperleucocytosis and hypoleucocytosis to indicate an increase and decrease in the number of leucocytes, using the word leucocytosis to mean the normal number of leucocytes.

The normal number of leucocytes varies within quite a wide range in healthy adults (5,000 to 10,500). People in a poor condition of nutrition but with no special disease have a low leucocyte count, with a reduced percentage of polynuclear cells, while those in vigorous health have a high leucocyte count, even approaching a slight leucocytosis, with an increased percentage of polynuclear cells.

The estimation of the number of leucocytes is of great value in the diagnosis and prognosis of disease, and aids materially in operative decisions, when considered in connection with other diagnostic and prognostic data. Considered by itself, it is useless.

It is highly important to keep in mind the fact that a leucocytosis may be physiological.

Varieties of Physiological Leucocytosis.—(*a*) New-born, (*b*) digestion, (*c*) pregnancy, (*d*) post-partum, (*e*) after violent exercise, massage and cold baths, (*f*) moribund state.

In the *new-born* there is a leucocytosis, varying from 17,000 to 21,000, greatly increased by digestion. This gradually decreases as the child grows older, until about the sixth year, when it approaches the normal adult standard. It must be kept in mind that the leucocyte count of a child is greatly influenced by the backwardness or forwardness of its development.

Attention to *digestion leucocytosis* is often overlooked in the estimation of leucocytes and in the deductions drawn therefrom. After a meal rich in proteids the leucocyte count may increase in health about 33 per cent. A vigorous person whose fasting leucocyte count is 9,000 may have a count of 12,000 three to four hours after a meal. The best time for making a fasting leucocyte count is before breakfast, since during the day there is more or less digestion leucocytosis most of the time. In certain diseases other than those of the digestive tract, there may be quite a marked digestion leucocytosis. Cabot gives the following examples:

In a case of pneumonia the count before food was 10,400, after food 21,700; in neurasthenia, before food 7,500, after food 13,500.

Any disease of the gastro-intestinal tract, whether functional or organic, may prevent the appearance of the digestive leucocytosis. In chronic gastritis there may be an absence of digestion leucocytosis, or it may be slight and late in appearing. In dilatation of the stomach it may be absent. In the majority of cases of cancer of the stomach it does not occur.

Pregnancy.—Most primiparæ show a moderate degree of leucocytosis during the later months of pregnancy, averaging about 13,000. It is not so common in multiparæ. The fact that in this condition there is no digestion leucocytosis suggests that the whole process may be a digestive leucocytosis.

The fact that there is normally a moderate leucocytosis during the post-partum period is of value, because it might be taken as an evidence of sepsis.

Violent exercise, massage, and cold bathing, such as the typhoid bath, cause a moderate, temporary leucocytosis, comparable to the digestion leucocytosis.

Moribund, or terminal, leucocytosis, occurs during the terminal stages of different diseases, and in most cases is due to peripheral stasis. In some cases it is thought that the terminal infections may be responsible. The increase in white cells is moderate and is usually in the polymorphonuclear cells; the count seldom exceeds 20,000 or 30,000. Occasionally, as in the case of pernicious anæmia reported by Cabot, the increase in the lymphocytes is so marked as to resemble lymphatic leukæmia.

Pathological Leucocytosis.—Cabot makes the following classification: (1) Post-hemorrhagic; (2) inflammatory; (3) toxic; (4) malignant disease; (5) therapeutic and experimental.

Theory Explaining Pathological Leucocytosis.—Present evidence tends to show that this process is a general one, involving the entire circulatory system,—that a drop of blood from the finger or the ear may be taken as an index of the blood condition in the deeper vessels of the body.

Leucocytosis is symptomatic of an excessive output and rapid development of leucocytes by the bone marrow due to the influence of *chemotaxis.*

The chemotactic theory may be stated as follows: The presence in the blood of certain chemical substances, produced by infective agents, is capable of exerting both an attractive and a repellent influence upon the amœboid leucocytes. If cells are attracted by such substances, the phenomenon is known as a positive chemotaxis; if they are repelled, it is called negative chemotaxis. This effect upon the cells of the blood may be produced by bacteria or their products,—necrotic tissue which has gained entrance to the circulation, and thermal and mechanical irritants. It would seem that different varieties of leucocytes—polynuclear neutrophiles, eosinophiles, lymphocytes—respond to different stimuli; in one instance we have an ordinary leucocytosis—as in pneumonia, in which the polymorphonuclear cells are chiefly increased; in another, as in trichiniasis, an eosinophilia; in a third, a lymphocytosis.

It seems reasonable to conclude that leucocytosis is a conservative process on the part of nature, and represents an attempt to destroy the infectious agent or its product by mechanical means, *i.e.*, phagocytosis; or by chemical means—the production of chemical substances (alexins) which act as bactericidal or antitoxic agents. Grabit-

schewsky states that these processes are most active at the period of maximum leucocytosis.

Just previous to the development of leucocytosis, there is usually a stage in which the leucocyte count is low. This is called by Löwit the *leucopenic phase.* Goldscheider and Jacob have proved that this is dependent purely upon an altered distribution of the cells in favor of the deeper vessels.

Pathological leucocytoses differ from the physiological in being usually of larger extent and of greater duration, and in being almost always accompanied by a relative and absolute increase in the poly(morpho)nuclear leucocytes. There is also a change in the cell structure in certain cells. A small percentage of the poly(morpho)-nuclear cells resemble myelocytes, having a nucleus which is on the border line between the two cells. One to three per cent. of the cells have become so altered that they cannot be distinguished from myelocytes.

Post-Hemorrhagic.—Following a large hemorrhage there is usually within an hour a considerable leucocytosis—from 16,000 to 18,000. In hemorrhage from the stomach this disappears again in a day or two, while in ordinary traumatic hemorrhage it persists longer.

Inflammatory and Infectious.—To the clinician the determination of leucocytosis in the numerous infectious and inflammatory conditions is of more practical value from the standpoint of diagnosis and prognosis, than the leucocytosis in all other conditions.

In the consideration of this variety of leucocytosis and in the deductions to be drawn from it, it is well to keep in mind the following facts.

There is no direct connection between leucocytosis and fever, since many febrile processes—typhoid fever, for instance—run their entire course, if uncomplicated, without leucocytosis, even showing a hypoleucocytosis.

Purulent and gangrenous processes usually cause a higher leucocytosis than serous processes (compare empyema and pleurisy), but the amount of leucocytosis depends on the severity of the infection and the resisting power of the patient. A leucocytosis which increases from hour to hour suggests an acute spreading inflammatory process, and its detection is of great value in cases of acute appendicitis in influencing the surgeon regarding his operation and prognosis. Wright and Joy (*Medical News,* April 5th, 1902) come to the following conclusions from a study of one-hundred and twenty-four cases of appendicitis in which they have blood records, and about as many in which they have no records.

1. The leucocyte count is a valuable aid to prognosis in appendicitis.
2. This is distinct from its diagnostic value.
3. A high stationary, or an increasing count, indicates a morbid condition of increasing severity which demands operation no matter what the clinical symptoms may be.
4. A low stationary or decreasing count indicates that the severity of the case is abating and that an operation may be safely postponed. Cases in which a falling count is accompanied by unmistakable signs of a generally bad condition form the rare exception to this general principle, and in them there is no chance of error.
5. No arbitrary set of prognostic values to be assigned to various degrees of leucocytosis can be constructed. The important point is to follow any scheme in which one learns to have confidence, provided the essential principle be preserved.
6. The count indicates when operation should be performed for the best interests of the patient.
7. Circumstances often render it desirable to postpone operation in appendicitis. Study of the blood renders it possible to determine whether this may be done with safety and often renders such postponement permissible.

When appendicitis is walled off and stationary, leucocytosis is less than in the advancing process and does not increase from hour to hour.

Leucocytosis is present in the following inflammatory diseases (Cabot):

Asiatic cholera, relapsing fever, typhus fever (according to the majority of observers), scarlet fever, diphtheria and follicular tonsillitis, syphilis (secondary stage), erysipelas, bubonic plague, yellow fever (some cases), pneumonia, smallpox (suppurative stage), malignant endocarditis, puerperal septicæmia, and all pyæmic and septicæmic conditions, actinomycosis, trichinosis, glanders, acute multiple neuritis (febrile stage), acute articular rheumatism, septic meningitis and cerebrospinal meningitis, cholangitis, cholecystitis, empyema of gall bladder, acute pancreatitis, endometritis, cystitis (some cases), gonorrhœa; abscesses of all kinds and situations,—felon, carbuncle, furunculosis, tonsillar and retropharyngeal abscess, appendicitis, phlebitis (some cases), pyonephrosis, perinephritic abscess, pyelonephritis, osteomyelitis, empyema, psoas and hip abscesses when not simply tuberculous, abscess of lung, liver, spleen, ovary, and prostate, salpingitis and pelvic peritonitis, epididymitis, pericarditis, peritonitis, arthritis (serous or purulent non-tuberculous), conjunctivitis, gangrenous inflammations of the appendix, lung, bowel, mouth (noma), many inflammatory diseases of the skin, such as dermatitis, pemphigus, pellagra, herpes zoster, prurigo, some cases of universal eczema. A miscellaneous class producing leucocytosis (toxic under Cabot's classification) includes that of illuminating-gas poisoning, quinine poisoning, rickets, uric-acid diathesis, gout, acute yellow atrophy of the liver, advanced cirrhosis of the liver (some cases), especially with jaundice, acute gastro-intestinal disorders (ptomaïns?), chronic nephritis, usually in uræmia cases, after injections of tuberculin and thyroid extract and of normal salt solution (intravenous), after ingestion of salicylates, potassium chlorate, or phenacetin, during or after prolonged chloroform narcosis, ether narcosis (according to some observers).

Malignant Disease.—The position of the tumor, its size, rapidity of growth, the number, size, and position of its metastases, and the resisting power of the patient—all have a marked effect upon the number of leucocytes in malignant disease.

There may be a leucopenia in cancer of the œsophagus, due to the starvation which a new growth in that location causes. If the cancer is small and without metastases—as in the early epithelioma of the lip—the leucocyte count is normal. Excessively high counts are never found. In rapidly growing and extensive neoplasms of the lung, liver, and kidneys counts of 50,000, 40,000, and 28,000 have been made. Sarcoma usually produces a more frequent and larger leucocytosis than carcinoma. When all cases are considered, absence of leucocytosis is perhaps more common in malignant disease than is its presence.

Therapeutic and Experimental.—Pohl found that most of the so-called tonics and stomachics produce a slight leucocytosis in animals. Winternitz injected a large variety of substances subcutaneously, and found that the degree of leucocytosis was parallel to the degree of local reaction excited.

Lymphocytosis is an absolute and relative increase in the circulating lymphocytes. The ordinary white count cannot of course determine this fact, but resort must be had to the differential count of stained films. A moderate white count might show a lymphocytosis. If lymphocytosis is associated with an increase in the total white count it cannot be distinguished from lymphatic leukæmia except by the history and physical signs. If we take the adult blood as our standard, lymphocytosis is normal for healthy infants. Certain of the diseases of infancy increase the lymphocytes remarkably—such as cholera infantum, rickets, various intestinal troubles, scurvy, hereditary syphilis, and especially pertussis, which disease, according to Meunier, may quadruple the lymphocytes. There is no rule governing the size of the lymphocyte; sometimes it is the larger, sometimes the smaller, and often no division can be made between the two.

In many debilitated conditions in the adult, the percentage of lymphocytes is increased—due simply to a diminution in the number of polynuclear neutrophiles. This must not be called a lymphocytosis.

The diagnostic value of lymphocytosis is seen chiefly in the diagnosis of lymphatic leukæmia, when associated with the presence of glandular tumors. Whooping-cough must first be proved absent. If associated with eosinophilia it may suggest obscure syphilitic disease.

Eosinophilia is an absolute increase in the number of eosinophiles in the circulating blood. There is a variation of from 25 to 500 per cubic millimetre in the healthy adult blood. Physiologically, eosinophilia occurs in young infants, and in women during the menstrual period and after coitus.

Pathologically, it has been reported in a large number of diseases, but from the standpoint of practical diagnosis is of more value in trichiniasis than in any other disease. The following list of diseases in which eosinophilia is found with the greatest regularity is taken from Da Costa:—

Diseases of the Skin.
- Dermatitis herpetiformis.
- Eczema.
- Leprosy.
- Lupus.
- Pellagra.
- Pemphigus.
- Prurigo.
- Psoriasis.
- Scleroderma.
- Urticaria.

Parasitic Diseases.
- Helminthiasis.
- Ankylostomiasis.
- Ascaris lumbricoides infection.
- Oxyuris vermicularis infection.
- Tænia mediocanellata infection.
- Trichiniasis.

Diseases of Bones.
- Hypertrophy.
- Osteomalacia.
- Malignant neoplasms.

Post-febrile Conditions.
- Malarial fever.
- Pneumonia.
- Rheumatic fever.
- Scarlet fever.
- Septicæmia.
- Bronchial asthma.
- Spleno-medullary leukæmia.

James Rae Arneill.

LEUCOPENIA.—An absolute reduction in the number of leucocytes in the circulating blood below the lowest normal limit is termed leucopenia, or hypoleucocytosis. It is the opposite of leucocytosis or hyperleucocytosis. The lowest normal limit is usually given as 5,000 per cubic millimetre. It is rather seldom in any condition that the leucocytes fall very much below 3,000 per cubic millimetre. Koblanck reports a remarkable case of leucopenia in an epileptic man twenty-five years of age. In a careful examination of twenty stained cover-glass preparations, he found only *one* leucocyte. Cabot refers to an unusual case of lymphatic leukæmia, in which the white count fell from 40,000 to 419 per cubic millimetre in the course of three weeks as the result of the development of an acute septicæmia. There are two classes of leucopenia—(1) physiological, (2) pathological.

Physiological leucopenia may occur after prolonged cold baths, short hot baths, and stimulation of sensory nerves. A change in the distribution of the leucocytes in the vessels takes place as a result of vaso-motor influences. Malnutrition and starvation are prominent factors in causing a reduction in the number of leucocytes. The faster Lucci showed a decrease in his leucocytes from 14,530 to 861 per cubic millimetre after a seven days' fast. This number increased to 1,530 on the eighth day, and remained at about this figure during the remaining twenty-two days of the fast. If disease is excluded, the number of leucocytes—especially the polymorphonuclear—may be taken as an index of the patient's nutrition. A low leucocyte count indicates poor nutrition.

Pathological Leucopenia.—It is rather difficult to separate leucopenia and a simple absence of leucocytosis. The fact that some of our most important diseases (when devoid of complications) show an absence of leucocytosis, is a remarkable aid in diagnosis. The following diseases are included in this list: typhoid fever; tuberculosis, including incipient phthisis; miliary tuberculosis, tuberculous peritonitis, tuberculous ostitis and periostitis, tuberculous pleurisy, tuberculous pericarditis.

If, during the course of these diseases, a leucocytosis develops, it points to the presence of a new factor; in typhoid fever, for instance, one of its numerous complications should be suspected and looked for, such as phlebitis, perforation, hemorrhage, peritonitis, abscess, bronchitis, etc.

Pulmonary tuberculosis inevitably becomes a mixed infection as the lesions increase, with a resulting leucocytosis.

Da Costa states that leucopenia, or, at least, an absence of leucocytosis, may occur during the course of the following additional infectious diseases: measles, influenza, malarial fevers, Malta fever, and leprosy. A combination of an intense infection and feeble resisting power may result in a very low white count, as in certain cases of pneumonia and appendicitis.

A well-marked leucopenia may be expected in about one-fourth of the cases of chlorosis, and in about three-fourths of the cases of pernicious anæmia. In some very severe cases of secondary anæmia and in splenomegaly it is found. Chronic gastro-enteritis in infancy reduces the white count below the normal. An intercurrent infection may produce a leucopenia—as in Cabot's case referred to above. Various investigators have produced a decrease in the number of leucocytes by the administration of various substances hypodermically. Bohland found that it followed the injection of ergot, sulphonal, tannic acid, camphoric acid, atropine, agaricin, and picrotoxin. Delezene injected various anticoagulant substances, peptone, diastase, and eel serum, with a resulting marked leucopenia.

The leucopenic phase which precedes the development of leucocytosis has been referred to above, in the article on leucocytosis.

In typhoid fever there is a gradual decrease in the number of leucocytes after the first week, the lowest counts being found during the fifth and sixth weeks. This rule, according to Winter, does not hold good in all cases, but it is so constant that if in a given case of non-eruptive fever the number of leucocytes is normal or subnormal, it would be a strong point in favor of the diagnosis of typhoid fever. There is a progressive diminution in the percentage of the polymorphonuclear cells which continues into the stage of early convalescence. The percentage of lymphocytes is increased throughout the fever, the increase being most marked in the stage of convalescence. The degree of the leucopenia corresponds in a general way to the severity of the disease (not taking into account the effect of complications). Counts as low as 2,000 and 3,000 are not very rare. In pernicious anæmia the white count runs parallel with the red count and the hæmoglobin per cent. In some cases it is very low, falling to 1,000 per cubic millimetre. As stated above, leucopenia is found in about three-fourths of the cases of pernicious anæmia, which is in marked contrast to the tendency toward leucocytosis in secondary anæmias.

Ehrlich believes that in these conditions there is a lessened proliferative function of the bone marrow, which results in a diminution in the output of leucocytes by this organ. *James Rae Arneill.*

LEUCOPLAKIA. See *Tongue, Diseases of.*

LEUCORRHŒA.—This term furnishes another illustration of the very common error, in medical terminology, of confusing a symptom with the condition of which it forms but a part or a phenomenon. Current use, especially after the lapse of a long period of time, so fixes such errors that it is almost a hopeless task to make the correction which is necessary or at least desirable.

The term which is in common use as the synonym of leucorrhœa is "whites," which is sufficiently expressive, for leucorrhœa etymologically means a white discharge or flow. But there may be white discharges from various parts of the body, especially from mucous membranes; moreover the color of the leucorrhœal discharge is not always white, hence the correctness of the term is not at once evident.

The white discharge or flow which is to be considered proceeds from the mucous membrane of the female geni-

tal organs, and in common language any white discharge flowing from the vagina is referred to as leucorrhœa. In the majority of instances it is a glandular secretion, and may be discharged from the glands or epithelium of the vagina or uterus. Its color is by no means always white; it may be brown, green, or yellow when purulent, or red when mixed with blood.

It is composed of serum mingled with epithelial cells, with leucocytes, or with blood or mucous corpuscles, according as its color is brown, white, red, or yellow. Its reaction is acid when it is derived from the vagina, and alkaline if derived principally from the interior of the uterus. It may be bland and unirritating, or viscid, acrid, and excoriating.

It is odorless, if discharged very soon after it is secreted, but is more or less offensive if retained very long within the vagina or uterus. Its consistency is that of water, pus, or mucus, with a specific gravity which varies according to the admixture and weight of the various substances which may be combined with the watery basis. It may be thin and watery, thick like the white of egg, or semi-fluid like the pus from an abscess. A discharge of this character may always be considered abnormal, for the genital mucous membrane in health secretes only so much material as may be necessary for its lubrication; hence the more abundant the discharge or the more complex its character, the more it is an evidence of disease.

The quantity or volume of a leucorrhœal discharge varies within wide limits. There may be only an almost inappreciable moisture, which, however, may be sufficiently annoying on account of its irritating action and the staining and soiling of the garments, or there may be a continuous dripping which requires the use of a napkin.

Its effects and consequences vary greatly in different cases, and are not always commensurate with its quantity or even with its physical qualities. It may cause no great disturbance aside from an unpleasant sense of moisture and wetness, or it may produce the most profound irritation and corrosion, the epithelium of the vagina and vaginal portion of the cervix being macerated, with accompanying erosion and ulceration, and the skin being chafed, inflamed, or necrosed. The local condition may react unfavorably upon the system in general.

The debility produced by the constant abstraction of fluid from the blood, by the intense itching which is almost intolerable by day and worse by night, and by the absorption of more or less toxic material, shows the possible deleteriousness of a condition which under ordinary circumstances is hardly thought worthy the dignity of serious notice.

Pain is a not infrequent accompaniment. Under the ordinary conditions in which there is merely a milky or watery discharge there is no pain, but when the discharge is associated with acute inflammatory conditions very severe pain may be present. This symptom is quite distinct from the mere annoyance of the discharge or the irritation and itching which are caused by the chafing and excoriation of the skin. The other well-known symptoms of inflammatory conditions, swelling, heat, and redness, are, of course, present in greater or less degree.

There is probably no morbid condition to which the female genitals are susceptible which is of such frequent occurrence, in some form or other, as the leucorrhœal discharge. It may be present in infants, in young children, in young adults, in mature women, and in the aged. It is probable that it is for this reason that some gynæcologists of wide experience have insisted that it is not necessarily an abnormality. With this sentiment I cannot agree, for, as already stated, the function of the mucous membrane is not to secrete a discharge which shall be appreciable and annoying, and if such a discharge is secreted the conclusion is only a logical one that it is due to some violation or fault of the natural law.

The grouping or classification of the various conditions in which leucorrhœa is present is not an easy matter. The field is so large that it is difficult to treat it with satisfactory comprehensiveness. It must always be remembered that leucorrhœa in itself is a symptom and not a disease, and as it always has a cause we are hardly justified in applying to it that unfortunate term *idiopathic*, which has always seemed to me a subterfuge for ignorance.

We can certainly differentiate its presence in those diseases or morbid conditions which are acute and in those which are chronic. It is also perfectly apparent that it is a symptom both in those diseases which appertain almost exclusively to the genital organs, and in those which are general or constitutional. Of the diseases of the genital organs the acute infectious ones are the most common, especially those which are known as venereal diseases.

Syphilis is essentially a chronic disease, and leucorrhœa when occurring as one of its symptoms may be considered under this category.

Chancroid is an acute venereal disease but is not so frequent in women as in men. The ulcer or sore which is its essential characteristic may be located upon the opening of one or both of the vulvo-vaginal glands or upon any portion of the mucous membrane of the vagina or the portio vaginalis of the neck of the uterus. Inflammation attends the development of this disease and is accompanied by a leucorrhœal discharge which is at first purulent, then muco-purulent, sometimes streaked with blood, or merely mucous and viscid. It is more abundant in young than in mature women and seldom produces constitutional symptoms that are of importance.

The treatment consists in the use of astringent applications to the sore or ulcer, astringent vaginal douches, and a vaginal tampon of cotton wool properly medicated. I am accustomed to apply the solid nitrate of silver daily to the sore, followed by a vaginal douche of at least two quarts of very hot water and an injection of one or two ounces of peroxide of hydrogen, then applying a tampon moistened with a two-per-cent. mixture of ichthyol in glycerin.

By far the most common form of infectious disease of the genital organs giving rise to a leucorrhœal discharge is *gonorrhœa*. The part which is primarily infected may be the vulvo-vaginal glands or the mucous membrane of the vagina or vaginal portion of the cervix. The original focus of infection usually enlarges, whether in circles or in straight lines we do not know, attacking one portion of mucous membrane after another, until the entire mucous tract from the vulva to the junction of the mucous membrane of the Fallopian tubes with the peritoneum may be involved. The process may even extend to the peritoneum, and indeed we know that this actually occurs in not a few instances. After the period of congestion in such cases comes the period of discharge, and the vagina is constantly bathed with a fluid which is purulent, tinged with blood, muco-purulent, and then mucoid. It is always intensely infective, the period during which it continues being variable, depending upon the age and physical condition of the patient, the treatment which is given, etc. In young women the discharge is more abundant, more virulent, and more persistent than in those who are mature or aged. The tissues involved are extremely sensitive, and pain and swelling are pronounced and decisive.

During the first few days of the disease the tissues are so swollen and tender that little can be done except to keep the skin of the external genitals as clean as possible. A simple method of accomplishing this is to place a pad of absorbent cotton over the genitals, holding it in position by means of a snugly fitting napkin. It may be necessary to replace pad and napkin by clean ones five or six times daily. When the swelling and sensitiveness have somewhat subsided the patient should be placed in the Sims position, a large Sims speculum being introduced, and the secretion removed from the entire mucous surface with absorbent cotton and with the utmost care and gentleness. The entire surface may then be carefully swabbed with a strong solution of nitrate of silver

(two drachms to the ounce of water) and the vagina tamponed with cotton wool saturated with a two-per-cent. mixture of ichthyol in glycerin. This treatment must be repeated daily until the discharge has diminished, the intervals of application being then lengthened gradually, but it must not be discontinued until all discharge has ceased. It is absolutely imperative that this treatment be carried out regularly and systematically, as it may prevent the extension of the disease to the bladder, Fallopian tubes, and ovaries. I have also found it useful to administer internally an antiseptic, such as the salicylate or the benzoate of sodium, which may be given in ten-grain doses in an aromatic water before meals. The consequences of this disease may be so serious that too much care cannot be taken in giving it the most intelligent treatment which is possible.

The discharge which proceeds from the interior of the uterus cannot be treated so early as that which proceeds from the vagina, but as soon as the acute inflammation of the uterus has subsided it should be carefully removed from the canal with a cotton-wrapped probe or sound and the nitrate-of-silver solution then applied over the entire surface of the uterine mucous membrane. It must be remembered that violent treatment of the uterus during the acute period of inflammation will not only give intense pain but may excite metritis of a severe type, or even peritonitis. If the uterine discharge cannot be readily removed in the manner indicated it is better to wait a few days and then to scrape the entire endometrium with a dull curette.

The leucorrhœa which follows *abortion* is quite similar in its characteristics to that of gonorrhœa, indeed it is often of gonorrhœal origin. The discharge in such cases usually proceeds from the uterine canal and is purulent or muco-purulent in character. It may be thick and tenacious and is sometimes removed with difficulty. It is better that it be not removed at all than that violence be used in attempting to remove it. It proceeds from the entire surface of the endometrium and may come also from the mucous surface of the Fallopian tubes. The latter occurrence is rare, for the uterine ostium of the tubes in these cases is usually swollen and impervious and the material which is secreted is retained, forming a tumor of greater or smaller dimensions. The period during which an abundant discharge from the uterus occurs in this disease, the acute period, usually extends over one or two weeks. It then subsides under proper treatment or it may become chronic and continue indefinitely. The applications of the nitrate-of-silver solution and the cotton-wool tamponnade should be used for this disease in the same manner as for gonorrhœa, but it should be remembered of course that the disease is not always of gonorrhœal origin. If gonorrhœa is not present the discharge is neither so infective nor so virulent as that which accompanies the specific affection.

A leucorrhœal discharge is often a sequel of *parturition*, differing decidedly from the ordinary lochial discharge. It implies that inflammation has followed the parturient process, which may be the awakening of some latent focus of disease in some portion of the mucous tract of the genital apparatus. This discharge may be purulent or muco-purulent, and more or less profuse and irritating, and under ordinary conditions continues for from one to three or four weeks. It is unwise to disregard it, and it is usually treated effectively by morning and evening vaginal douches of hot water, which is made sufficiently astringent by the addition of alum or tannic acid, in the proportion of a tablespoonful to the quart of water.

During *pregnancy* a leucorrhœal discharge from the vagina is not unusual, resulting from the congested condition of the vessels. It is often very annoying from the irritation to the skin which it causes and the constant soiling of the clothing. It usually yields to the systematic use of astringent vaginal douches.

A discharge of a purulent character frequently follows *surgical operations* upon the genital organs, especially in those cases in which primary union has not taken place. The treatment should consist in the use of astringent vaginal douches twice daily, and the constant application of a snugly fitting vulvar pad of absorbent cotton.

Injuries to the genital organs are usually followed by an abundant discharge from the vagina, constituting the customary discharge of an inflamed mucous membrane. Such injuries may be due to blows or thrusts with sticks or other substances, falls astride a chair or fence, brutality, rape, etc. They may be attended with great pain and swelling of the affected tissues. The chief considerations in their treatment are rest and cleanliness, the secretions being removed from the vagina with care and thoroughness at least once a day, and astringent vaginal douches being taken twice daily. The principle of treatment is that which applies to wounds in general, rest being an important factor in such treatment. Walking, working, or anything which causes motion of the diseased tissues tends to weaken the recuperative forces of nature.

Excessive coitus and *masturbation* are frequent causes of leucorrhœa. The repeated congestions of the mucous membrane in such cases furnish sufficient explanation of its mode of origin. The discharge is usually white or milky, and is often profuse, and irritating to the skin. It is the more troublesome as the individual is careless as to the conditions which provoke the discharge. The treatment is such as has already been indicated for similar conditions.

Little children are sometimes the subjects of leucorrhœa caused by the irritation of *worms*. Either the large round worms (lumbricoids), or the small seat or thread worms (ascarides) will produce this condition. The discharge is frequently profuse and annoying, irritating and excoriating the skin, and making the child's life miserable. It is usually brown in color and viscid in consistency. I have found it a most difficult condition to cure until the worms are discovered and destroyed. It will usually be necessary to examine the patient under anæsthesia, dilating the entrance of the vagina with the finger if necessary. The vagina should be irrigated with a hot solution of boric or salicylic acid (one drachm to the quart of water), and the irrigation repeated daily until all congestion of the vaginal mucous membrane has disappeared. Of course a suitable cathartic must be given to dislodge the parasites from the rectum, and the ordinary rules of hygiene must be carefully regarded.

Of the *chronic* conditions and diseases of the genital organs which give rise to a leucorrhœal discharge it may be stated that they are the outcome of the acute diseases, and the failure to cure the latter implies that treatment has been defective. Such a result is by no means infrequent, especially with the venereal diseases. In syphilis, while the initial sore may be healed in a short time the constitutional derangement may be so great that a discharge from the vagina may continue indefinitely in spite of the most judicious local and general treatment. It is therefore necessary to be patient in our endeavors to check it, and not be too positive as to the prognosis, especially as to the time which may be required. In chancroid, which is entirely a local disease, the healing of the sore will be followed by the cessation of the leucorrhœa, if there is no other cause for its continuance. The leucorrhœal discharge which accompanies gonorrhœa is often very persistent. Especially is this the case when the ovaries and tubes become the seat of a chronic inflammatory process. If the ovaries and tubes are removed the leucorrhœal discharge will usually cease. The leucorrhœa which attends abortion, pregnancy, and parturition is usually quite amenable to treatment and seldom becomes chronic, unless there is such disease in the uterus and its appendages that severe surgical measures will be required to remove this fundamental cause.

The leucorrhœa which accompanies *dysmenorrhœa* is often prolonged and tedious. If it is due to a deformed and immature condition of the uterus it is usually remedied by pregnancy, but pregnancy does not often occur when such a condition of the uterus obtains. A surgical

operation will sometimes bring relief, but is not an infallible remedy.

The leucorrhœa in little children which is caused by worms is also one of the varieties which are often chronic and persistent, chiefly for the reason that the cause may fail to be discovered and removed. There is often very strong objection, on the part of parents, that their children should be subjected to the necessary examination and treatment, and it is frequently their fault that the condition remains obscure and uncured.

The leucorrhœa which occurs in aged women, technically known as *senile vaginitis*, is essentially a chronic disease. It sometimes proceeds from the vagina alone, and sometimes from the uterus as well. The discharge is usually a dirty, watery, acrid fluid which irritates the mucous membrane and skin, causing the most intense itching, and the rubbing and scratching to which it gives rise produce the most annoying and even painful results. The tissues become swollen and excoriated, and the patient is deprived of peace and comfort by day and by night. The general health is often as greatly deranged by this form of leucorrhœa as by any in the entire category. Nevertheless, I have seldom seen a case in which great relief could not be obtained by careful and persistent treatment. An examination must first be made, and if the source of trouble is found to be within the uterus, the endometrium must be thoroughly curetted. The uterus and vagina must be irrigated with an astringent solution (alum or tannic acid) and the vagina tamponed with cotton wool saturated with a mixture of subnitrate of bismuth and glycerin, enough of the former being added to the latter to make a rather thick paste. This paste must also be smeared over the swollen and inflamed external genitals. The treatment should be repeated every day or every second day until a cure has resulted. Many cases of this character have come under my observation and the treatment which has been alluded to has invariably brought relief.

The leucorrhœa which is an accompaniment of *malignant disease* of the uterus and vagina is susceptible only of palliative treatment. The discharge is profuse, watery, and very offensive. Curettage, irrigation with strong astringent solutions, and tamponade of the vagina will give a certain degree of relief, but the result will be uniform and uniformly fatal unless extirpation of the diseased organ is practised at a very early period.

We now come to the subject of leucorrhœa which occurs as a secondary phenomenon in the course of some constitutional or general disturbance. The list of diseases which may have this symptom is a long one, and the characteristics of the discharge are such as to make this the typical form of leucorrhœa as it is ordinarily considered. Foremost among these diseases may be mentioned those in which there is a chronic condition of malnutrition, the leucorrhœal discharge being one of the elements of its expression. The tissues are relaxed, the tension of the blood current is low, there are stasis of the venous circulation and transudation of serum and corpuscles in the vagina where the vessels are numerous and the resistance is slight. Diseases which at once suggest themselves as possessed of these conditions are tuberculosis, malaria, anæmia, chronic rheumatism, and the various forms of chronic, slowly progressing nervous disease. Those who suffer from excessive obesity, with its accompanying impairment of circulation, may also be placed in this category.

Another class of cases includes individuals who suffer with the infectious diseases, typhoid fever, scarlet fever, diphtheria, and measles. In such cases there is congestion of the genital organs, and the discharge sometimes continues long after all other symptoms of the disease have disappeared. Especially is this the case with children, and often, in addition to the leucorrhœa, an impression is produced upon the structure of the uterus—whether as the result of toxic influence or of interference with the circulation, is not known—which permanently affects its development and lays the foundation for future trouble which may prove of a serious nature.

Yet another class of cases includes those in which the causative influence is transient in character but may recur an indefinite number of times. Illustrations of such a cause are climatic variations, especially great heat and dampness, fatigue and emotion, particularly the extremes of emotion which are experienced by the hysterical and by those who are passing through the menopause. In all these varying forms of disease, if leucorrhœa is present as a symptom (and it frequently is present), there is one characteristic discharge which is usually observed, viz., the white watery variety, more or less abundant, more or less irritating, more or less persistent, and more or less pronounced in its debilitating and irritant effects.

The treatment for leucorrhœa in the three classes of cases last mentioned must consist primarily in the treatment of the cause. With such diseases as tuberculosis, syphilis, anæmia, etc., the local symptom is not usually removed by any form of local application or manipulation, however judicious or skilful, until the underlying cause is either removed or greatly ameliorated. If the discharge is due to an infectious general disease, such as one of the specific fevers, it will tend to self-limitation, but it may continue a long time after the fever has disappeared, and permanent lesions of the sexual organs, with leucorrhœa as one of their persistent accompaniments, are frequently attributable to such a cause. If the discharge is due to emotional causes, hysteria, etc., the removal of the cause is almost a hopeless task, for the changing of one's nature and characteristics is not a common occurrence. It is certainly proper in all these various cases to impress upon the patient's mind the necessity for the observance of a most careful personal hygiene, whether any medicinal or surgical treatment is employed or not. The constant use of the vulvar pad of absorbent cotton, the employment, morning and evening, of the vaginal douche with a hot astringent solution, and rigid attention to the skin, the bowels, the diet, the sleep, and the mode of occupation, may be more serviceable than any amount of professional attention.

The prognosis for this condition depends upon many factors. It is frequently entirely curable, recurring if the original cause is repeated, or it may be of a character which will preclude radically successful treatment, as in the case of malignant diseases. Its importance is sufficiently great to warrant careful study on the part of every physician who may be called upon to treat the disorders of the female sexual apparatus. *Andrew F. Currier.*

LEUKÆMIAS, THE.—(Synonym: Leucocythæmia.)

Definition.—The leukæmias are diseases of unknown causation (possibly varieties of the same disease), characterized anatomically by overgrowth of hæmatopoietic tissue, myeloid or lymphatic, infiltrations in the various organs of the corresponding leucocytes, myelocytes, or lymphocytes, and, when unmodified by treatment or intercurrent disease, accompanied by a great, usually an extreme increase of the circulating white cells of the same type.

Historical Account.—This unusual and most interesting malady was first recognized and described in October, 1845, by Hughes Bennett and independently a few weeks later by Virchow. The former published the account of an autopsy upon the body of a man who died, with a much enlarged spleen and liver, and whose blood was filled with corpuscles which Dr. Bennett described as exactly resembling pus. In his discussion of the case he laid stress upon the absence of phlebitis and of the evidence of local suppuration in the body, which separated the condition clearly from pyæmia, or pus absorption, and he reached the conclusion that he was dealing with a new and distinct pathological process, in which pus corpuscles in great number originated within the blood itself. How far the hypertrophy of the liver and spleen was concerned with the change in the blood he was unwilling to say. Virchow, in his original publication, not only described independently a similar case, but came to the conclusion, which has been substantiated by all subsequent investigation, that the corpuscles in question

were not pus, but the white cells of the blood, present in many times their normal number. He also inclined to the view that there was some direct relation between the splenic enlargement and the diseased condition of the blood. Reviewing an older case of Rokitansky's, which had been diagnosticated "general pyæmia," he correlated it with his own and proposed the name leukæmia, or white blood, for the disease. Upon this followed a prolonged controversy with Bennett—who now adopted the name leucocythæmia (white cell blood)—for the honor of priority in discovery and concerning the true nature of the newly recognized pathological condition. A few older cases, all included under pyæmia, were brought to light, and now that the attention of physicians everywhere was directed to the disease, reports of new cases were soon forthcoming. With this increasing material Virchow continued to elaborate his theories as to the real nature of the process, and in a series of articles made great additions to our knowledge of the leukæmias. He early described a case which differed from all preceding ones in presenting marked enlargement of the lymphatic glands throughout the body, accompanied by an increase in the small and not the large white cells of the blood. This he named lymphatic leukæmia, calling the previously described disease splenic.

Since the pioneer work of Virchow the study of leukæmia has been of marked interest to pathologists, and its true nature forms, even yet, a part of that great debatable territory of medicine into which theory and speculation press eagerly, while exact knowledge, by the slow acquisition of one fact after another, makes but gradual encroachment on its borders. The nature of the leukæmias is of course so intimately associated with the still unsolved problem of the physiology of the blood-making organs, of the normal mode of formation of blood, and especially of the white cells in the adult, that of late years it has been studied mostly by those who have devoted themselves to hæmatology. In this period of many theories and much valuable work it is hard to choose the most important, but Ehrlich's studies in staining and the introduction of his methods in the investigation of the blood during life, the recognition of acute leukæmia by Ebstein and the study of its blood changes by Fränkel, and Neumann's work on the rôle of the bone marrow in the pathology of leukæmia, have been perhaps the most notable. Of the various theories which have played so large a part in the history of our knowledge of the disease, we shall treat later.

Varieties.—The older writers distinguished two forms of leukæmia on the basis of their gross anatomical features: the splenic type, in which the spleen is enormously enlarged, and the lymphatic, with a somewhat enlarged spleen but with general enlargement of the lymphatic glands. Later, when Neumann had demonstrated the constant presence of a characteristic change in the bone marrow in the splenic cases, these were called splenic-myelogenous—the term still most frequently employed. Since that time marrow changes of equal importance, but of a different type, have been found in lymphatic leukæmia and they probably exist in all cases, and very interesting cases of leukæmia without any anatomical changes outside of the bone marrow have been reported. The investigation and classification of the leucocytes, since the pioneer work of Ehrlich, have led to many changes in the theories held as to their derivation. The part which the spleen is known to play in their origin has been narrowed to insignificant dimensions. The bone marrow and the lymphoid tissues have been proved to be the great centres of leucocyte proliferation, and the distribution of lymphoid tissue has been found to be far wider than previously supposed, areas of it existing even in the bone marrow itself. Whether we follow Uskoff, Löwit, and Gulland in regarding all forms of leucocytes as merely different stages in the development of a single cell, or believe with Ehrlich and Ribbert that they are so many distinct cell types, it is clear that a nomenclature which is based upon gross anatomical changes is misleading from the pathological standpoint, and, since the spleen is enlarged in lymphatic leukæmia and the lymph nodes may be in the splenic variety, it is unsatisfactory clinically as well.

The subdivision made by Ehrlich and Lazarus fulfils all practical and theoretical requirements in the light of our present knowledge and will be adopted here. It distinguishes two forms: "1. Myelogenous leukæmia—leukæmic processes with growth of myeloid tissue; 2. Lymphatic leukæmia—leukæmic processes with growth of lymphoid tissue."

Under lymphatic leukæmia we may well consider acute leukæmia as a clinically distinct type; whether from theoretical considerations it should be regarded as a different process from chronic lymphæmia is perhaps an open question.

Myelogenous Leukæmia.

(Synonyms: Splenic-myelogenous, splenic, myelocytic and leucocytic leukæmia; myelæmia.)

Occurrence.—This, by far the most usual form of leukæmia, is still to the average practitioner a very rare disease. Bramwell, in the analysis of 141,777 consecutive medical cases, found only 5 of leukæmia. It would appear to be more prevalent in the United States than in England and is quite frequently met with in Russian Poland. In this country the highest percentage has been reported by Dock from the University Hospital, Ann Arbor, viz., 11.3 cases of leukæmia in 10,000 admissions.

Predisposing Conditions.—In a disease so infrequent, statistics are not to be relied upon. Men are said to be more commonly affected than women, and adults to show a larger preponderance of the myelogenous form over the lymphatic than children. It has been attempted to show that an antecedent malaria predisposes to the development of leukæmia. Injuries over the spleen have been followed by the disease; in one case which I have seen, only a short interval elapsed; but whether there was a direct connection between the two must be pure conjecture.

Onset, Course, and Termination.—The onset in the great majority of cases is gradual. The patient's attention will first be called to the slow failure of health, to the change in color, to the fulness and distress caused by the enlarged spleen, or to pain in the splenic region. In some cases a rise of temperature daily is an early symptom. Priapism occasionally is among the first complaints. The course of myelogenous leukæmia is essentially chronic. In most cases there are periods, sometimes of considerable length, when the disease remains stationary or even recedes. Some cases are more subacute, with fever and progressive anæmia. Rarely, sudden hemorrhage may be the initial symptom.

The termination is invariably fatal. That genuine leukæmia is ever recovered from must be doubted, for cases in which recovery has been recorded were probably of extreme leucocytosis, the report of the blood findings in older cases not sufficing to differentiate the two conditions. Bramwell reports a case of apparently acute myelogenous leukæmia with recovery under quinine; but here again the blood was examined only in the fresh state.

General Clinical Description.—During the early stages of the disease there is nothing in the appearance of the patients to suggest the existence of so grave a malady, and as a rule they do not seek medical advice until it has been established for some time. Before the custom of making examinations of the blood for diagnostic purposes was thought of, many cases were undoubtedly overlooked, either throughout their whole course or until a late stage. The apparent anæmia is usually but slight; there is some loss of weight and of strength; but apart from the examination of a stained blood specimen nothing may arouse the physician's suspicion until the enlargement of the spleen becomes prominent.

As the disease progresses this splenic tumor is usually the most conspicuous feature. It is associated with some and often considerable enlargement of the liver, so that the abdomen becomes quite prominent, in contrast with

the emaciated condition of the thorax and extremities. In a well-marked case there is generally some pallor of the skin and mucous membranes, or a muddy color; but some patients are not visibly anæmic, and the apparent anæmia is always less than in any other condition with the same reduction in hæmoglobin, this being due without doubt to the marked increase in the opacity of the blood from its excess of white corpuscles and to the abnormal fulness of the vessels which ordinarily exists. In fact, even a leukæmic plethora has been described.

Emaciation becomes considerable with the advance of the process. There is digestive disturbance. The patients are troubled, on exertion, with dyspnœa, palpitation of the heart, and faintness. General lassitude and disinclination to exertion are marked. Tenderness of the bones is present in some cases. A slight or moderate febrile movement, most often attaining its maximum in the afternoon, is not uncommon.

In all these features there is the widest variation in different cases, and in any individual there may be remissions in any or nearly all of the symptoms for considerable lengths of time, with or without treatment. Late in the disease a tendency to hemorrhage becomes prominent and this may be the direct cause of death, especially when the hemorrhage is in the brain. Other causes of a fatal issue are intercurrent infections, such as pneumonia, suppurations, and ulcerative processes in the mouth or throat. Nephritis occurs in some cases as a terminal event and patients die extremely emaciated and dropsical after weeks of suffering, worn out with the disease itself.

The duration ranges from six months to several years, the general average being from one to three years. The longest case which I have seen lasted four years.

There are exceptional cases of myelogenous leukæmia which deserve special notice. One of the rarest forms, but one of the most interesting, for an understanding of the real process, is that in which there is no enlargement of the spleen, liver, or lymphatic glands, the bone marrow alone showing the characteristic changes. This form is sometimes called pure myelogenous leukæmia, in contrast to the ordinary splenic-myelogenous type; but, as the blood picture is the same in both forms, and as they are both alike in all other respects, it seems better to speak only of myelogenous leukæmia.

Contrasted with these are cases in which enlargements of the lymphatic glands occur, without increase of the lymphocytes of the blood. These have been erroneously considered a mixed form of the disease, but when they present only the myelogenous blood type it does not seem right to class them as such. The nature of the enlargements will be explained later. Another interesting and very rare condition is the so-called "dermal leukæmia."

Special Pathological Anatomy and Physiology.—The Blood. The blood changes of leukæmia are best studied during life and constitute the most reliable diagnostic evidence of its existence. The gross appearance of the drop obtained by puncture may be normal, but usually it is somewhat paler and of a more opaque and muddy hue. It may resemble a mixture of blood and pus. The older writers described especially the peculiar white or creamy color and friable nature of the clots found in the heart and vessels after death. In blood that has been kept for a time Charcot-Leyden crystals can usually be found. Fibrin formation is not more rapid than in health.

Leukæmic blood is difficult to spread in a thin layer, and the preparations for staining must be made with especial care. For its accurate study the examination of stained films is absolutely essential, and methods which show the granulations of the leucocytes must be used. Formerly the distinction between leukæmia and leucocytosis was held to be a quantitative one; in other words, a purely arbitrary line was drawn to separate the two blood states. Now we know that the most far-reaching qualitative differences exist, in every way equivalent to deep-seated anatomical changes in other tissues.

Quantitative changes.—With the exception of cases under treatment or suffering from intercurrent disease, which will be considered later, the blood in myelogenous leukæmia shows a diminution in the number of red cells and a great, usually enormous, increase in white cells. Accompanying the decrease in red cells is a reduction in the content of hæmoglobin in the blood; but the quantitative estimation of this by the colorimetric methods, Gowers', von Fleischl's, etc., is not accurate, the changed color of the blood rendering a satisfactory comparison with the scale impossible. The oligocythæmia is in most cases moderate, the red cells averaging about 3,000,000 per cubic millimetre, but in the later stages, and especially if severe or repeated hemorrhages occur, it may be extreme. I have seen one case of two years' duration in which the red cells shortly before death were only 800,000. The increase in white cells, on the other hand, is generally so great as to justify the older clinicians in having considered it pathognomonic; but some reported cases, especially those under arsenic treatment, have shown no increase whatever. As a rule the number of leucocytes exceeds 100,000 per cubic millimetre and it may pass 1,000,000.

Qualitative changes.—It is in the study of these that we find the essential features of the blood in myelogenous leukæmia. The word which best expresses the picture which a stained specimen presents is "polymorphous." In no other condition is so great a variety of cell types present. Ehrlich and Lazarus sum up under four heads the changes which are now generally regarded as constituting the specific characters of the blood:—

1st. That, in addition to the polymorphonuclear cells, their antecedents, the mononuclear granulated leucocytes (myelocytes, marrow cells), also circulate in the blood.

2d. That the three types of granulated leucocytes—the neutrophilic, eosinophilic, and basophilic (mast cell)—all participate in the increase in the number of the white cells.

3d. That atypical cell forms, dwarf forms of the various white cells, and cells showing karyokinesis, appear.

4th. That nucleated red cells are constantly present, often in great number.

These changes are all demonstrable in every case of myelogenous leukæmia unmodified by treatment or intercurrent disease, but in varying combination. In some the neutrophilic myelocytes are the most noticeable abnormal feature; in others the great numbers of eosinophilic cells, and in still others the mast cells. The extent to which atypical cell forms and nucleated red cells appear differs widely in individual cases. The typical picture, once seen, cannot be mistaken for anything else. The distinguishing feature is to be found, not in the presence of the mononuclear neutrophilic cell, the ordinary myelocyte, but rather in that of mononuclear cells of all three types of granulation, with atypical forms and nucleated red cells. Ehrlich previously laid great stress on the increase in eosinophiles as pathognomonic. Certainly no other condition shows them so uniformly exceeding their normal absolute number per cubic millimetre, though their relative number may not be greatly changed. Dwarf forms of leucocytes are often conspicuous. Karyokinetic figures occur, but they are of great rarity and of no value for diagnosis. The nucleated red cells present are almost always normoblasts, but occasionally megaloblasts and intermediate forms appear.

Other changes which should be mentioned are the presence of slight poikilocytosis and polychromatophilic changes in the red cells, the amount depending on the severity of the anæmia; also the occurrence of white cells which, in their staining reactions, show degeneration. These are so marked in some cases as to be classed as an essential feature.

An intercurrent inflammatory process, which is ordinarily accompanied by a polymorphonuclear leucocytosis, may have a profound influence upon the blood picture. A great reduction in the total leucocyte count usually occurs and with this a qualitative change, the myelocytic character of the blood becoming less and less conspicuous, until in some cases the polymorphonuclear cells attain the proportions of an ordinary leucocytosis, even to ninety per cent. of the total white cells. Mononuclear granulated cells are not entirely absent, how-

ever, nor are nucleated red cells. Another interesting feature is the persistence of some eosinophiles, which, under similar conditions in the non-leukæmic, entirely disappear from the circulation. Sometimes a severe infection will cause a veritable leucopenia.

Continued dosage with arsenic in certain patients produces a similar reduction in the number of the white cells, which may be extreme and may result in a condition closely resembling primary pernicious anæmia. Usually the qualitative changes are less marked than the quantitative, and even with a normal leucocyte count the diagnosis would be evident from the cell types present; but cases have been reported in which there were present both a permanent normal count of white cells and an absence of the leukæmic characters so nearly complete that a diagnosis from the blood was impossible; yet the leukæmic process continued to a fatal issue. Two most interesting cases of this kind are reported by A. E. Taylor, from the Pepper Laboratory of Clinical Medicine of the University of Pennsylvania. In all cases the effect of arsenic upon the oligocythæmia and the nucleated red cells seems to have been slight. This is in marked contrast to the remissions of pernicious anæmia so commonly seen under this treatment, during which the number of red cells rises rapidly;—remissions which are also observed independently of this treatment.

The Bone Marrow. Though constant and marked changes are here present, in only a portion of the cases do they give rise during life to symptoms, such as tenderness of the sternum, tibiæ, etc. The characteristic lesion is the so-called "pyoid" transformation first described by Neumann. This occurs even in bones which ordinarily have no blood-making function, and consists in an overgrowth of the true myeloid tissue, which replaces the fatty marrow and usually encroaches on the shaft of the bone, causing rarefaction and an actual enlargement of the medullary cavity. The proliferated tissue is yellowish-gray in color and often shows areas of softening and hemorrhage. There may also be some increase in the red erythrocytic portion of the marrow, as is seen in severe anæmias.

Microscopically, this "pyoid" marrow shows a multiplication of the true myelogenous elements, the mononuclear and polymorphonuclear neutrophilic and eosinophilic cells, the mast cells, and the macrophages, with evidence of rapid division. There is a marked disturbance of the mechanical circulatory conditions by the hypertrophied tissue, and infiltrations may be found in the walls of the blood-vessels. Areas of excessive pigment accumulation and of necrosis are also seen.

The Spleen. Marked enlargement of the spleen is one of the most characteristic features of this form of leukæmia. The normal shape and the direction of its long axis are usually preserved, but occasionally the latter assumes a more transverse position. The lower border almost always reaches below the level of the umbilicus, often to the left iliac fossa, and I have seen a spleen which, besides increasing enormously in size, had become so twisted on its pedicle that it lay across the abdomen, almost filling this cavity, and resting with its previously external surface on the two iliac fossæ. The liver in this case was crowded posteriorly and the stomach and small intestines were pushed up under the ribs. Palpation will usually reveal one or more well-defined notches in the anterior border (a point of differentiation from tumor of the kidney), and often depressions at points on the surface. These depressions, which are found at autopsy, are due to scars of previous infarctions. Such infarcts at the time of their occurrence are accompanied by local inflammation of the overlying peritoneal coat (perisplenitis), causing rise of temperature for several days and local tenderness, with sharp pain on movement or respiration. Auscultation or palpation over such an area during respiration discloses a friction rub. The splenic tumor in itself is the cause of considerable discomfort. Its size may vary considerably from time to time, but tends to increase with the progress of the disease. There is no direct relation between its variations and those of the blood. Exceptionally, the spleen may shrink during the latter weeks of life. Post mortem the capsule is found much thickened, often adherent to surrounding organs, and showing the scars mentioned above. On section the consistency is found to be firmer than normal, the color is reddish or yellowish brown, and the Malpighian bodies are not visible or are less distinct than normal. There are pigment accumulations, hemorrhagic areas, and infarctions of various ages.

Histologically, there is seen a great infiltration of the splenic pulp and crowding of the splenic sinuses with the leukæmic white blood cells. Nucleated red cells and pigmented leucocytes are common and the macrophages seem increased. Karyokinetic figures are not frequent and hyperplasia of the Malpighian bodies or evidence of active cell production in them is not present. There is new connective tissue throughout, with fibroblasts. This evidence points to the splenic enlargement being the result of leukæmic infiltration and the production of fibrous tissue, and therefore a secondary change. The principal increase of function of the organ seems to be hæmolytic, in connection with the increased destruction of red blood cells.

The Lymphatic Glands. The connection of these with myelogenous leukæmia is a purely secondary one. They are usually to be found somewhat enlarged, but only in rare cases sufficiently so to be noticeable during life. There is not a hypertrophy of the true lymphoid tissue, but simply an infiltration with leucocytes, the same in kind as that described in the spleen, but less in degree. These leukæmic infiltrations are found in most of the organs of the body and are among the most characteristic lesions. In a few cases the lymph glands have been found to be much increased in size, but without blood changes of the lymphatic type. To call such cases lymphatic-myelogenous leukæmia is to magnify an anatomical peculiarity.

The Liver. The liver is increased in size, sometimes to a considerable degree. The enlargement is easily detected during life. Its normal shape is preserved, and the edge is thin. The surface is smooth and the consistency firm. Microscopical examination shows the presence of infiltrations throughout, especially in the portal spaces. The parenchyma cells show a marked fatty change.

The Circulatory System. The lesions here are all of a secondary nature. Infiltrations are found in the heart muscle and rarely in the walls of blood-vessels. The heart cavities may be dilated, petechial hemorrhages may be present in the peri- or endocardial surfaces, and the muscle is usually less firm than normal and pale or somewhat fatty, as in chronic anæmias. The disturbances of function are more striking. Weakness of the heart's action is a symptom which increases with the progress of the case, as evidenced by a frequent soft pulse, dyspnœa on exertion, and a tendency to dizziness or fainting attacks. Abnormal physical signs, if found, will be those common to anæmic states, a systolic murmur in the pulmonic area or at the aortic and mitral openings as well, and perhaps also over the carotids, with the venous hum. Œdema is present in the late stages.

Hemorrhages. The tendency to hemorrhages is so marked in many cases that it is one of the classical symptoms. The anatomical basis for it has not been satisfactorily elucidated, and we do not yet know whether it is to be found in leukæmic infiltration of the vessel wall or in some change of the kind which produces a similar tendency in other anæmic states. The commonest bleedings are from the nose and gums, then from the stomach and intestines; occasionally also hæmaturia is seen. The most dangerous form is cerebral hemorrhage and death from this is a termination to be borne in mind. Deafness from bleeding in the internal or middle ear is a rare accident. I have seen a case in which this occurred on both sides and was recovered from. The most easily studied vessel changes are in the retina, and these will be separately described.

Leukæmic Retinal Changes. The most common is the condition of great enlargement of the retinal veins, with arteries of normal size. The fundus is usually paler than

normal. Small infiltrations in the retina may sometimes be seen with the ophthalmoscope as little whitish spots, and occasionally swelling and inflammation of the disc are found. These changes are spoken of as constituting leukæmic retinitis.

The Genito-Urinary System. Leukæmic infiltrations are usually marked in the kidneys, especially in and about the glomeruli. The organs themselves are apt to be enlarged, with smooth surface, and paler than normal. The tubular epithelium shows cloudy swelling or fatty changes. The influence of these changes, as revealed in the urine, is not great, but albuminuria may be present, especially late in the disease. Recently a true acute or subacute parenchymatous nephritis, coming on as a terminal event in some cases, has been described as a leukæmic change.

The urine in leukæmia usually contains an excess in total uric acid. This condition is now thought to be due to excessive nuclear metabolism, leucocytes being especially rich in nuclear compounds; but whether the breaking down of nuclear substance is in the circulating white blood cells or in the hæmatopoietic organs, is not surely known. As before mentioned, hæmaturia may occur as an expression of the hemorrhagic tendency of the disease. In a recent case I observed a positive diazo reaction during the last two months of life. In the male sexual organs the occurrence of priapism, probably due to circulatory obstruction in the corpora cavernosa, is the only symptom of importance. In the female, uterine hemorrhage is frequent.

The Skin. The color is usually paler than in health and often muddy, but in some cases there is no visible anæmia, and the face may even be plethoric. Various eruptions have been described in connection with leukæmia, but probably they are of merely coincident occurrence. In Virchow's original case there was a general pustular eruption, which he held to be purely secondary. Petechial hemorrhages are of a closer relationship. One extremely rare and interesting condition, described as "dermal leukæmia," has a very definite connection with the disease itself. About twelve cases of this kind are on record, the first one having been observed by Biesiadecki. The condition occurs in both varieties of leukæmia. Multiple tumors of small size are present in the skin and form a prominent feature of the clinical picture. These tumors histologically are infiltrations similar to those found in the internal organs.

The Digestive System. Apart from the liver there are no important changes either in structure or in function. Infiltrations occur, especially in the wall of the intestine. Severe ulcerations in the mouth and throat not infrequently lead to a fatal tissue. Ulcers are also found in the intestines.

As in all chronic diseases, digestive disturbance is the rule and loss of appetite, vomiting, constipation, etc., are frequent. Obstruction of the bowels from the pressure of the enlarged spleen has been reported. Some of the vomiting may be due to the same cause. Diarrhœa at times proves intractable and is the cause of fatal exhaustion. Ascites may occur, but is never of serious dimensions.

The Respiratory System. This is not directly involved in the disease. The diminished capacity of the thorax, due to the pressure upward of the increased intra-abdominal contents, is in part responsible for the dyspnœa. Bronchitis, pneumonia, and œdema of the lungs are common causes of death.

The Nervous System. Ollivier and Ranvier have described in detail many disturbances of the nervous system that occur in leukæmia, and as a rule in its terminal stages. Headache, vertigo, and syncopal attacks are the earlier and, as they say, prodromal symptoms. Later, an apathetic condition may develop with increasing somnolence merging at last into coma, more or less prolonged, but always terminating in death. Convulsions have occurred just before death and a condition of maniacal excitement has been described.

Cerebral hemorrhages have been found at autopsy, either large or small and multiple. The cerebral and spinal vessels have been seen enormously distended with the peculiar brick-red or chocolate-colored blood. Such a condition must be associated with increased intracranial pressure and be the probable cause of the later symptoms. Death by apoplexy is of course the result of sudden hemorrhage of large size. Of the earlier attacks of faintness, headache, vertigo, etc., cerebral anæmia is alleged as the cause. Whether this is so or not, there is certainly marked disturbance of the cerebral circulation. I have seen one case in which intense vertigo came on suddenly and persisted for weeks on any attempt to rise, and was followed by total deafness, but which eventually ended in recovery. The most plausible explanation of the symptoms seemed to be a hemorrhage into the semicircular canals and internal ear.

Body temperature. Leukæmia is not a febrile disease, but some fever is usual during its later stages. The more rapid cases are accompanied by fever from the onset, most frequently of a remittent or intermittent type, with the maximum elevation in the afternoon. The attacks of perisplenitis usually cause elevation of temperature, and the intercurrent infections of course present their usual symptoms.

General Metabolism. Emaciation is a constant feature of the disease, sharply distinguishing it from primary pernicious anæmia. The appearance of the patients toward the close is cachectic. Experiments relating to metabolism have been made by several observers on leukæmic patients, but the disease is of such duration and variations in its progress are so common that most contradictory results have been obtained.

Lymphatic Leukæmia.

(Synonym: Lymphæmia.)

Occurrence.—This type of leukæmia, in either its acute or its chronic form, is said to be much less frequently met with than the myelogenous, though my experience has not borne out this statement.

Predisposing Conditions.—Practically nothing is known of the effect of antecedent conditions upon the development of the disease except that in rare cases a transition from Hodgkin's disease has been observed. These will be discussed later in considering the theories as to the real nature of the leukæmic processes. Patients with chronic glandular enlargements remaining after an adenitis, as in the cervical glands from inflammatory processes in the throat, have later suffered from this malady; but the frequency of such glandular enlargements is such that coincidence is very possible and no relationship need be postulated, though it is not to be excluded.

Onset, Course, and Termination.—From the clinical standpoint there are two distinct forms of the disease, the acute and the chronic, which some physicians consider, in many respects rightly, as sharply differentiated from one another. In their essential lesions, however, so far as we know them, such a line cannot be definitely drawn, and cases are seen which form a connecting link between the two.

Acute lymphatic leukæmia or acute leukæmia, as it is often called, begins for the most part suddenly, with pronounced symptoms, fever, hemorrhages from the nose, gums, or the mucous surfaces generally, purpuric spots in the skin, a rapidly progressive anæmia and slight or moderate enlargement of the lymphatic glands, spleen, and liver. In some cases, after a short period of less severe manifestations, the patients become rapidly worse. The whole course of the disease may cover only a few days, but usually it occupies five or six weeks and may be more protracted. It is in these longer cases that the separation from the chronic form is difficult. The result is invariably fatal.

Chronic lymphatic leukæmia, in its typical manifestation, is a slowly progressive affection, beginning with purely local manifestations and only in its later stages adding general symptoms to the picture of gradually increasing glandular enlargements. The duration varies

from months to several years. I have in mind at present one patient who lived for four years after the first swellings were noted. No cases have ever terminated in recovery.

General Clinical Description.—As has been said, *acute leukæmia* is a rapid, in many cases fulminating disease, with the picture of an acute purpuric affection and giving the impression of an intense infectious process. Its symptoms, quite unlike those of the chronic leukæmias, may precede the visible glandular or splenic tumors and the blood changes. The disease is always accompanied by fever, moderate as a rule, but sometimes considerable. The hemorrhages from any or all of the mucous membranes and under the skin are its most constant and characteristic feature. Coincident with these a profound anæmia develops, but whether this is secondary to the loss of blood, or is due to a toxæmia which is the common cause of both manifestations, is uncertain. The patient becomes rapidly exhausted and passes into a typhoid state, in which he dies; or delirium, stupor, or convulsions may occur. Severe and progressive ulcerations in the mouth and in other portions of the gastro-intestinal tract are common and rather characteristic occurrences. Marked gastro-intestinal disturbance, vomiting, diarrhœa, etc., are frequent, as in other acute diseases. An acute nephritis may also be present.

The glandular enlargements are at the most of moderate dimensions, and the spleen and liver never attain the size usual in myelogenous leukæmia. Tenderness of the bones is sometimes complained of. A very few cases have been reported in which neither the lymphatic glands, including the lymph nodes in the intestinal wall, nor the spleen were enlarged, but at autopsy marked lymphoid changes were found in the bone marrow.

In the very rapid cases in which death occurs within a few days of the onset, the diagnosis often is not made until the autopsy.

Chronic lymphatic leukæmia, or lymphæmia, is a disease which, apart from its characteristic blood changes, allies itself clinically more with Hodgkin's disease or other forms of lymphatic glandular tumors than with the types of leukæmia previously considered. That some intimate relationship with Hodgkin's disease exists is evident from the recorded cases of transition from the latter complaint. Some writers also speak of an "aleukæmic stage," meaning by this expression that the local symptoms may precede the development of the lymphatic character of the blood. In all cases, certainly the first manifestations are the enlargements of some or many groups of lymphatic glands. Those most often affected are the cervical, then the inguinal, retroperitoneal and mesenteric, axillary, etc. Some groups may escape considerable enlargement throughout the whole course, but in most cases all the lymph nodes of the body are at length affected. The tumors increase progressively in size, are painless, as a rule soft, though sometimes firm, and do not tend to break down or suppurate. The spleen and liver are moderately enlarged.

With these local symptoms we note an anæmia, usually moderate, such as is present in the myelogenous form, and emaciation, loss of strength, and other signs of general failure in health. Late in the disease a tendency to hemorrhages may appear. As a rule the patients die from intercurrent disease—local suppurations or ulcerations, which they resist badly, pneumonia, etc. Tuberculosis has occurred in several reported cases.

The duration may be several years, but as a rule it is from nine months to two years. Cases lasting from four to nine months are uncommon, but are occasionally noted; they form a connecting link between the acute and the chronic type. They are intermediate between the two forms in their symptoms also.

Unusual forms beside those already mentioned are the very rare cases without glandular enlargements, but with the blood state and other symptoms, in which, post mortem, lymphoid proliferation is found in the bone marrow.

"Dermal leukæmia," as already described, has been more commonly found in connection with lymphatic than with myelogenous leukæmia.

Whether cases of true mixed leukæmia, presenting the lesions and blood picture of both types, really occur is now called in question. In all probability the majority of such descriptions heretofore have been due to a confusion between myelocytes and lymphocytes, due to the insufficiency of the staining methods used for their differentiation. On the other hand, competent observers have reported cases which seem to admit of no other interpretation. At the best, such a combination must be of exceedingly rare occurrence.

Special Pathological Anatomy and Physiology.—The Blood. The gross appearance of the blood as obtained by puncture and collected from the vessels at autopsy is the same as already described under myelogenous leukæmia. Its quantitative changes are also very similar and it is influenced in like manner by treatment and by intercurrent disease The leucocytosis does not reach such extreme figures as in the myelogenous form, 450,000 per cubic millimetre being the highest count I have found in ten cases examined. From 100,000 to 300,000 per cubic millimetre in the chronic and below 100,000 in the acute cases are the usual figures. The oligocythæmia is apt to be more pronounced, however, and in the acute form rapidly reaches an extreme degree. I have seen one such case with only 800,000 red cells per cubic millimetre.

The characteristic change produced in the blood by lymphatic leukæmia is the tremendous increase in the absolute number of circulating lymphocytes. While in healthy blood these constitute less than thirty per cent. of the whole number of white cells, in this condition they form over ninety per cent. of a total leucocyte count, which is many times the normal. In many, at least, if not in all cases, there is an absolute decrease in the number of polymorphonuclear cells; eosinophiles are seldom seen and myelocytes appear only in rare cases. Hence we have a blood in which the white cells are almost wholly of lymphatic origin. Here we do not have to deal, as in the myelogenous blood, with the presence of vast numbers of cells which are foreign to the circulation in health, but with an abnormal increase in one of the normal types and an accompanying diminution in the others. From a theoretical standpoint this decrease in the leucocyte forms supposed to be derived from myeloid tissue, is of great interest.

The lymphocytes of normal blood can be differentiated into two classes, called large and small lymphocytes, distinguished from one another not alone by their size but also by their staining affinities, the small being about five times more numerous. In lymphatic leukæmia the increase may be confined wholly to one or the other of these forms, or it may affect both of them. In the chronic type the small lymphocyte as a rule predominates, though not invariably, as has been claimed.

Acute leukæmia, however, as first pointed out by Fraenkel, is characterized by the great preponderance of the large lymphocytes, and this most interesting fact has been made the basis of an attempt to claim a different pathological foundation for the two forms of the disease. I have, however, seen chronic lymphæmia with the same blood picture.

The lymphocytes in leukæmic blood, especially those of the large type, frequently stain with difficulty and show marked degenerative changes—evidence of the presence of dead cells within the circulation.

Nucleated red cells are present in much smaller numbers than in the myelogenous form, not more than would be found in a chronic anæmia of the same severity. In acute leukæmia a few megaloblasts may be found and occasionally a myelocyte. When the anæmia is severe, poikilocytosis and polychromatophilic changes in the red cells are present.

The Bone Marrow. The marrow lesions of lymphatic leukæmia, though in gross extent so much inferior to the glandular changes, are certainly of equal importance. The typical appearance is a bright red or grayish-red marrow, which may encroach somewhat on the fatty

marrow, but does not show the rarefaction of surrounding bone and increase in the marrow cavity noted in the "pyoid" change of myelogenous leukæmia. To the eye there may be no alteration visible. Microscopically, however, the lymphadenoid transformation, as Neumann has named it, is evident at once. Lymphocytes are in great abundance, but myelocytes, eosinophiles, etc., are less conspicuous than normal. This change is undoubtedly due to the overgrowth of lymph nodes normally present in the marrow, as has been conclusively demonstrated by Cornil and Neumann. The mechanical interference with the circulation, shown by the compression and dilatation of vessels, is present here, as are also the infiltrations into the vessel walls described by Benda. These may be agencies favoring the escape of the lymphocytes into the circulation. The compression of the myeloid tissue by the hypertrophied lymphoid marrow offers a plausible explanation of the diminished number of polymorphonuclear leucocytes and eosinophiles in the circulation and, to my mind, constitutes one of the strongest arguments for their myelogenous origin. Tenderness of the bones occurs less frequently than in myelogenous leukæmia.

The Spleen. Enlargement of the spleen is much less pronounced in this form of leukæmia, but is fairly constant, and its general character during life is the same as that of the splenic tumor of myelogenous leukæmia. It never encroaches on the right side of the abdomen and seldom reaches below the umbilicus. In acute cases the enlargement may be only slight.

The nature of the changes found after death, however, differs markedly. Instead of an infiltration with myelocytes, etc., there is a great increase in the lymphocytes throughout, and large collections of them are present. There is not so much connective-tissue increase. Infarcts, when present, are of smaller size. Hemorrhages and pigment accumulations are present.

The Lymphatic Glands. These, except in the rare cases mentioned, in which the changes are in the marrow alone, are enlarged, and as a rule very markedly so. When the disease is of long duration the neck becomes of tremendous size from the growth of the cervical chain. Often the increase is much more pronounced on one side. The glandular tumors are of varying consistence, but usually soft. They do not tend to spread out into the surrounding tissue nor to merge together. Besides the superficial and deep lymph nodes, the tonsils, thymus glands, Peyer's patches, and the solitary follicles of the intestine may be affected. It is also a question whether the lymphoid infiltrations in the various organs are in reality such, or whether they do not perhaps represent a proliferative action on the part of minute resident lymphatic collections.

During life the glandular tumors cause inconvenience but not actual pain. Rarely, the enlarged bronchial or mediastinal glands may, like other tumors within the chest, cause pressure upon important structures, particularly a bronchus, with serious results.

On section the color of the glands is pinkish to red and fresh hemorrhages may be present. Microscopically there is a great increase in the collections of large lymphocytes, which show karyokinesis; the small lymphocytes are also much increased and are closely packed together; there may be infiltrations of the blood-vessels. The collections of polymorphonuclear leucocytes and myelocytes which are present in the glandular enlargements of myelogenous leukæmia are not found, though polymorphonuclear cells, eosinophiles, mast cells, and macrophages are scattered here and there. Fibroblasts and proliferating endothelial cells are present, and also red cells collected in small extravasations. Degenerations in the cells are not infrequent.

Other Organs and Tissues. The lesions in the non-hæmatopoietic tissues correspond with those of myelogenous leukæmia, except that the cells composing the infiltrations are lymphocytes and not leucocytes of myelogenous origin. These infiltrations are most frequent in the liver, here situated in the periportal spaces, and are in part the cause of the increased size of the organ. They also occur in the kidneys, stomach, lungs, serous membranes, retina, and skin.

The disorders of function in like manner do not need a separate description, the essential features having been considered in the general clinical description. The great tendency to hemorrhages in acute leukæmia is the point of most importance.

Causation.—Of the actual cause of leukæmia we are still wholly ignorant. The several hypotheses concerning it are based only upon other theories as to the nature of the disease processes, and will be discussed in that connection. All attempts to cause the disease in animals by inoculations of the blood or of emulsions of the hæmatopoietic organs have failed.

Several observers have described bacterial forms as present in the blood during life in isolated cases, but without further proof of any causative relationship.

In 1899 Löwit reported the constant presence of sporozoa in the blood-making organs and in some of the circulating leucocytes of a number of cases of leukæmia. He distinguished two forms: one associated with myelogenous leukæmia, the other, found in lymphatic cases, acute and chronic, in Hodgkin's disease and in the so-called pseudo-leukæmic infantile anæmia of von Jaksch. He classes them with the malarial organisms and claims that they are the specific causes of the leukæmias, each of the form with which it is associated. His methods of demonstrating the organisms, however, are very complicated and were not disclosed at first, and the experiments which he reports as successful in inoculations of leukæmia are not at all convincing. His results so far have lacked confirmation by other observers. They are of interest especially in connection with the present investigations of numerous workers into the parasitic and perhaps causative nature of the cell inclusions found in malignant growths.

Nature of the Leukæmic Processes.—Since the early days of active controversy between Bennett and Virchow the real nature of the disease or diseases which we know as leukæmia has been one of the great debating grounds of modern medicine. Many theories have been advocated which could not bear a close analysis and were soon abandoned. Among them were Bennett's, that it is a suppuration of the blood; Löwit's, that it is due to a prolongation of the lives of the leucocytes and a retardation in their evolution; and the view that the affection is a cancer of the blood itself. The opinions which deserve consideration to-day can be grouped under two general hypotheses: the first, originally advanced by Virchow, that the disease is allied to the malignant tumors; the second, that the process is an infectious one and the blood condition a specific leucocytosis. According to the neoplasmic theory the local infiltrations are to be regarded as metastases, while, if the infectious theory be correct, they may be either mechanical depositions or areas of local leucocytosis due to a concentration of the chemotactic influence at particular points. In its fulminating course acute leukæmia has no analogue among the malignant tumors; but, on the other hand, the close resemblance between chronic lymphæmia and Hodgkin's disease, as well as lymphosarcoma, is much more easily interpreted by the first theory. Neither one is competent to explain all recorded facts, nor need we suppose that new facts will not arise which will alter our conceptions, not only of the leukæmic processes, but also of the great unsolved mystery of the tumors. Experiments on the effect of long-continued leucocytosis upon the hæmatopoietic organs, which are just beginning to be carried on, should also throw new light upon this vexed question.

Among the attempts to explain the apparently close connection between leukæmia and pseudo-leukæmia (Hodgkin's disease), Neumann's theory is of especial suggestiveness. He holds in general to the neoplasmic nature of the process, but teaches that "if the pathological stimulus to proliferation falls first or alone upon the spleen or lymphatic glands, whose elastic capsules expand with their growth, then only pseudo-leukæmia re-

Leukæmias.

sults; if in like manner the bone marrow is affected and brought to a condition of hyperplasia, then leukæmia will exist." The few observations of lymphatic leukæmia without enlargement of the lymphatic glands or spleen, especially those recently reported by Pappenheim, lend considerable support to this conception.

Diagnosis.—In the vast majority of cases the diagnosis, not only of leukæmia, but of the exact form present, is one of the easiest problems which the practitioner encounters, if only he has acquired the simple technique needed for the examination of stained blood films. The character of the blood has already been discussed and will not be reviewed here. Upon it depends the diagnosis. Leukæmia must never be confounded with leucocytosis, in which the increase is of the polymorphonuclear leucocytes, while in leukæmia of either type the mononuclear cells are in the majority.

An acquaintance with the clinical features of the disease will lead to a suspicion of its existence in most cases. Extreme enlargement of the spleen with enlargement of the liver is so much more common in myelogenous leukæmia than in any other condition, that no other diagnosis should be considered until a blood examination has been made. The importance of routine blood examinations in all cases of doubtful nature has been well demonstrated. Were this practice always followed the diagnosis of chronic malaria would be less frequent.

In acute leukæmia the diagnosis will be, as a rule, between that disease and an acute purpuric affection, and can be definitely settled only by finding the large lymphocytes in very great excess. Where considerable enlargement of the lymph nodes, spleen, and liver exists, there is little danger of confusion.

Chronic lymphæmia presents so exactly the external features of Hodgkin's disease that only a blood examination can give the clew to the real process. In Hodgkin's disease and in sarcoma of the lymphatic glands there may be a leucocytosis affecting both polymorphonuclear cells and lymphocytes, or a lymphocytosis of slight degree, and here a careful analysis of stained specimens is necessary. A hasty examination of the fresh blood might lead to the diagnosis of leukæmia, which should not be made except on the evidence of a predominance of lymphocytes of the extreme grade described. Infants at birth have the lymphatic blood picture, without increase in the total leucocytes, and throughout childhood slight causes will produce a leucocytosis of quite marked lymphatic type. This fact should be borne in mind when cases in early life come under consideration. A lymphocytosis equalling that of lymphatic leukæmia has been very rarely observed in acute infectious diseases, especially whooping-cough, in children, but the condition has disappeared immediately with the subsidence of the sickness.

The ill-defined pseudoleukæmic anæmia of infants offers some possibilities for confusion with myelogenous leukæmia, myelocytes being found in the circulation, but it does not present the complete polymorphous blood picture which has been described.

Rare cases of metastatic malignant growths in the bone marrow and multiple myeloma also may cause the appearance of numerous myelocytes in the blood; but no cases are as yet on record in which all forms of mononuclear granulated cells were increased.

Finally, in cases of leukæmia under treatment or during an attack of intercurrent disease, the diagnosis may be difficult or perhaps impossible. Here the standard of comparison should be, not the blood in health, but the blood picture of a non-leukæmic subject suffering from the disease present.

Prognosis.—As has been said, the ultimate recovery of patients suffering from this disease is not to be expected. The most that can be hoped is that the process will remain stationary for a considerable period, or will advance but slowly. The outlook in myelogenous leukæmia is, as a rule, more favorable to a prolonged course than it is in the lymphatic variety, though in the latter treatment seems more apt to be beneficial. Acute leukæmia may be expected to kill within three months from the onset of severe symptoms.

As regards the deductions which can be drawn from the symptoms as to the probable duration and the present condition of the patient, only a few general statements are possible. The best guides are the extent of emaciation and failure of strength and the condition of the digestive and circulatory organs. The total number of leucocytes is of only slight significance, but a steady increase points to advance of the disease. The actual size of the spleen, or of the lymph glands in lymphatic leukæmia, is of equally small importance, but progressive enlargement has the same significance as a constant increase in the number of leucocytes. The converse is not necessarily true, and patients have died under treatment with far lower leucocyte counts than in an earlier stage of their sickness. Diminution in the size of the spleen, in the absence of hemorrhages, diarrhœa, and other causes for decrease in the total blood volume, is usually favorable. Rapid or progressive fall in the number of red cells is a serious sign. Cases with fever are apt to run a more rapid course than afebrile ones. Symptoms of grave import are the larger hemorrhages, dropsy, and pronounced nervous disturbances. Ulcerations which advance in spite of treatment, or the development of bronchitis, pneumonia, or severe diarrhœa in the later stages, may lead quickly to a fatal issue.

Treatment.—In the absence of any knowledge of the true cause of the disease or a thorough understanding of the processes at work, our treatment of the condition itself must be wholly empirical. The only drugs which have seemed to exert any influence in checking the progress of the malady are arsenic and quinine. Löwit, on the ground of his supposed finding of the real cause in an organism allied to the malarial organism, advocates the use of quinine. Arsenic in certain cases causes a marked fall in the number of leucocytes in the circulation, in some even below the normal, but this has never been followed by recovery, though in all probability life has been prolonged. Sooner or later there is usually a relapse with increasing leucocytosis, but patients have died without the white cells rising again above the normal number. When this drug is given it should be pushed to the extreme limit of tolerance and continued indefinitely. This of course subjects the patient to the danger of arsenical poisoning.

Removal of the spleen has been attempted as a curative measure, but with a fatal result in most cases. General opinion holds the operation unjustifiable, and when it is proposed for tumor of the spleen a blood examination should always be made.

Feeding with splenic tissue and other animal extracts has no empirical or rational basis and can be expected to produce no results except digestive disturbance. Dr. William Ewart has recently advised inhalations of carbonic acid gas and reports rapid improvement under the treatment.

Measures of real importance for the patient's comfort, and probably not without influence on the prolongation of his life, are attention to general hygiene and the treatment of symptoms as they arise.

Patients suffering from leukæmia as from other chronic diseases should so regulate their lives as to obtain the maximum of enjoyment and usefulness with the minimum of fatigue. Many of them can for a considerable time continue some occupation with advantage. Sunshine and fresh air are beneficial. The food should be the most nourishing that can be digested. Late in the disease the patients are confined to bed and the digestive disturbance makes careful regulation of the amount and character of the food necessary. Laxatives should be given with special care, for uncontrollable diarrhœa may be the result of their injudicious use, and this same caution should be exercised in the administration of any drugs of doubtful utility. Most of all should an atmosphere of hopefulness be preserved, one of the most important adjuncts to the treatment of any incurable disease.

Several symptoms require special treatment. For the anæmia, beside the usual iron preparations, bone marrow (well tolerated when frozen as a kind of ice-cream) may be administered, and oxygen inhalations are useful. Of the effect of the newly exploited cacodylic acid on the anæmia of this disease I have no knowledge. The attacks of perisplenitis call for rest in bed and are best relieved by the local application of cold, preferably the ice-water coil. Painting with iodine, mercurial inunctions, and the faradic current have also been made use of to reduce the size of the spleen.

Other disturbances should be treated as they arise, it being always borne in mind that we cannot look for a cure of the disease, and therefore that we must make the patient's comfort, for the remaining short term of his life, our first consideration. *Theodore C. Janeway.*

LEVANT FEVER. See *Malta Fever.*

LEVICO.—Two mineral springs and a village bear this name, in Tyrol, Austria, just north of the boundary line of Italy. The town has about 6,000 inhabitants and is situated at an elevation of 1,700 feet above sea-level, on a large mound of shale at the southern slope of Monte Fronte and Monte Canzana. It is surrounded by the beautiful mountain scenery of the southern Tyrolese Alps, in the picturesque valley of Valsugana, a little more than an hour's ride by rail from Trent. A short distance up the valley, at the end of a rather steep ascent, are two beautiful lakes, Caldonazzo and Levico, the source of a small rivulet, the Brenta, which flows down the valley, and, after attaining considerable size, crosses the Venetian plain, to empty into the Bay of Venice.

The mineral springs issue from two grottoes in the side of Monte Fronte at an elevation of fully 3,000 feet above the sea. They are known as the Vetriolo and the Ocra (or Ocker), and, in reference to the comparative strength of their waters, as the weaker and the stronger. The most remarkable feature of the waters is that they contain considerable quantities of iron, arsenic, and manganese, in addition to many other mineral salts. Some analyses show also free acids. One thousand parts have been found to contain:

	Vetriolo.	Ocra.
Cupric sulphate	0.0470	
Ferric sulphate	4.3210	
Ferrous sulphate	.0290	0.4008
Manganese sulphate	Trace.	
Aluminum sulphate	.8428	
Magnesium sulphate	.1504	.2630
Calcium sulphate	1.0520	.1320
Sodium sulphate	.0120	
Arsenious acid	.0008	.0099

There are also small quantities of the oxides of iron, aluminum and manganese, and some free carbonic acid gas.

The water has been found beneficial in all conditions for which iron and arsenic are indicated, hence in the different forms of anæmia, chlorosis, neuralgia, and other nervous affections, especially hysteria, neurasthenia, and chorea, in skin diseases, in uterine and ovarian affections, and in gastro-intestinal disorders.

At the springs, only the weaker water is administered internally, the stronger being used for bathing. Both are generally diluted with pure spring water in proportions prescribed by the attending physicians. Both waters are bottled, however, and are on sale in all parts of the world. The patient is directed to begin with one tablespoonful of the weaker water, well diluted, or a third as much of the stronger, morning and evening. The dose is increased every third or fourth day until three tablespoonfuls are taken after each meal.

In the bathing institutions at Levico there are, in addition to the ordinary baths, all facilities for special hydrotherapy, massage, and all forms of electrical treatment. *James M. French.*

LEVULOSE. See *Sugar.*

LEYSIN, SWITZERLAND.—This mountain village is a high-altitude resort, 4,150 feet above the sea-level, situated in Western Switzerland at the junction of the Ormont and Rhone valleys, a few miles from the eastern end of Lake Geneva. It is easily reached from Paris by rail to Lausanne and Aigle, and thence by diligence and an electric road.

Pulmonary tuberculosis is the principal disease treated at this resort, although the climate is recommended for bronchial asthma, chronic bronchitis, anæmia, convalescence from pneumonia and pleurisy, neurasthenia, tuberculous conditions in children, and obstinate dyspepsia. The climate is favorable for a continuous residence the year through. The peculiarities of a high-altitude climate, such as have been described under Davos and elsewhere in the HANDBOOK, are exhibited at Leysin: a comparatively dry, pure atmosphere, a large amount of winter sunshine, freedom from mists and high winds, and intense solar radiation, characteristic of the attenuated air of altitudes. The meteorological data are similar to those given under Davos. The average winter temperature, however, is somewhat higher than that at Davos, ranging from a minimum of 21.7° F. to a maximum of 35.6° F. at 7 A.M., and from a minimum of 25.8° F. to a maximum of 39.1° F. at 10 A.M. The lowest temperature observed was −2° F. The sun temperature in winter is between 86° F. and 122° F., while the ordinary temperature is between 32° and 50° F. The mean relative humidity for the five winter months, November to March inclusive, for the three winters 1887–90, was 61.9 per cent. There are on an average from five to five and a quarter hours of sunshine a day, though the possible daily insolation is, of course, greater. The total number of hours of sunshine for the five winter months from 1887–90, was as follows: 1887–88, 482.70 hours; 1888–89, 601.05 hours; 1889–90, 737.6 hours, or a little over four hours a day.

In the four years 1887–90 the percentage of calm days (absence of wind) was 81. Wind, therefore, is the exception. The prevailing direction of the wind is from the southwest and southeast. Fog or mist is rare.

Leysin, then, well fulfils the conditions of a high-altitude health resort, which are: (*a*) purity of the atmosphere; (*b*) dryness; (*c*) absence of wind; (*d*) intense insolation; (*e*) low temperature; (*f*) diminished barometric pressure.

Above the village of Leysin, which is itself situated on a plateau, is the plateau of Feydey, 610 feet higher, and here is situated a sanatorium with a large annex. To the north, northeast, and northwest rise chains of mountains which afford protection from the winds blowing from these directions. The sanatorium is situated on the border of great forests of fir trees which clothe the mountain sides. In front of the sanatorium is a great terrace looking toward the south, and affording a wide and extended view. This sanatorium, which with its annex, has one hundred and forty chambers, is equipped with all the appliances for modern sanatorium treatment, and is under skilful medical direction. The tuberculous who are most likely to improve in this, as in all high-altitude health resorts, are those whose general condition is good, and in whom the involvement of the lungs is not too extended or active, as indicated by continuous pyrexia. The best time of the year in which to begin a residence in Leysin is in August or September.

As has been mentioned above, the "cure" can be continued the year through, though for those who spend the winter in the south Leysin affords a favorable summer climate. There are many attractive mountain excursions about Leysin, and in the winter there are skating and tobogganing. There are Catholic and Protestant churches, shops, and attractive chalets which can be hired for the season. The postal and telegraphic facilities are good.

To one desiring to take the high-altitude cure in a well-conducted sanatorium and at the same time gain a knowledge of French and French people, Leysin can be recommended. *Edward O. Otis.*

FIG. 3193.—Sanatorium of Leysin (4,800 feet above sea-level).

LIBERTY, SULLIVAN COUNTY, NEW YORK.—Sullivan County occupies a position near the summit of the eastern water-shed of the Delaware River, south of the Catskill Mountains at a point where the boundaries of New York, New Jersey, and Pennsylvania meet. The country is beautiful, hilly, but not wild; it is devoted to dairy farms and supports a prosperous community. There are no large bodies of water near, no swamps or stagnant water-courses, and rapid drainage gives to the air a dryness not found in the lake region or at the seaboard. The soil in the lower levels is a loam with a moderate amount of clay, but on the hillsides it is more porous. The range of temperature is great; there are usually four months of sleighing, the snow which falls in November remaining dry and hard through March. The mean annual temperature is 44° F., and the mean annual rainfall about fifty inches.

The death rate for Sullivan County and for Delaware County adjoining is the lowest in the State, being about one-third that of New York City. The native population is of hardy Dutch stock with very little foreign blood.

The neighboring towns of Liberty Falls, Fallsburg, Woodburne, Youngsville, Parksville, Neversink, Monticello, and Hurleyville, although not quite so high as Liberty (elevation 1,600–2,200 feet), share in great measure its natural advantages and are attractive for summer residence.

As a winter resort Liberty is attractive. There are about one hundred hotels and private houses that afford accommodations during the summer. Access is by the New York, Ontario, and Western Railway in about four hours from New York.

Liberty was selected by the late Dr. Alfred L. Loomis as the site of the sanatorium which now bears his name. This institution was opened in 1896 and has been liberally equipped for the treatment of tuberculous patients. There are two departments: one for patients paying from fifteen to thirty dollars weekly, and a charitable annex for patients paying five dollars weekly. Special arrangements can be made for private cottages and suites. There are at present nineteen buildings with a total capacity of 125. Only those patients are desired who are in the early stages of consumption, and to whom a residence of a number of months in the sanatorium promises a complete cure or such an improved condition that they can return to their homes and be able to carry on their work. Both men and women are admitted. Patients are required to remain at least eight hours a day out of doors unless excused on account of sickness or during rainy weather. Climate is not wholly relied upon in the treatment of patients, for use is made of appropriate medical treatment as well. There is, in connection with the sanatorium, a training school for nurses which educates them in ministering to the special needs of tuberculous patients.

Liberty has acquired a wide reputation for the treatment of pulmonary tuberculosis on account of the success of this sanatorium, but during the past year local sentiment has been aroused against the consequent influx of visitors having this disease. The village authorities have passed a regulation prohibiting the maintenance of any institution or house for the reception of patients having tuberculosis within the limits of the village. The Loomis Sanitarium, at a distance of two miles from the station, does not fall under this restriction.

Guy Hinsdale.

LICHEN.—The term lichen, as applied to diseases of the skin, has, until comparatively recently, been loosely given to a variety of cutaneous eruptions, characterized by itching papules of a chronic type. Reminders of this loose nomenclature are found in the terms, still occasionally employed, lichen tropicus (miliaria rubra), lichen simplex (eczema papulosum), lichen urticatus (a variety of erythema exudativum multiforme), and lichen scrofulosorum.

French writers of to-day use the term lichenification to describe a condition of the skin found as a sequel to long-continued inflammations of various sorts. It is characterized by the appearance, particularly at the various joints, of small, flat-topped papules, resembling more or less closely those of lichen planus. It is not a definite disease, runs no characteristic course, and in this country would be considered merely a form of papular eczema.

As now understood, the term lichen includes two diseases only, and the identity of these two has been affirmed by some dermatologists. The first variety, lichen planus, is not extremely rare, but is by no means one of the common diseases of the skin. The second, lichen ruber acuminatus, is one of the most infrequent of the dermatoses. Typical cases of these diseases are markedly different from one another, but atypical cases are sometimes seen, which present characteristics of both.

Lichen Planus.—A typical case of lichen planus begins upon the flexor surfaces of both forearms, or upon the sides of the abdomen, with moderate itching or tin-

Fig. 3194.—Lichen Planus. (A. R. Robinson.)

gling sensations, followed in a few days by an eruption of small, flat-topped, thickly clustered, highly distinctive papules. They are fairly uniform at first, each being of about the size of the head of a pin. Each is separated from the others by normal skin. But their most striking characteristics are their color and shape. At first dull crimson in hue, they later assume a violet, purple, or lavender tint, which is so different from that of any other eruption that the diagnosis may often be made from it alone. The shape of the papules, too, is highly characteristic. Each has a flat top, with just the suggestion of a dimple near its centre, and perpendicular sides, with angular corners. Another feature of the individual papule which attracts attention is a peculiar waxy sheen, especially noticeable when viewed from one side.

The disease does not continue indefinitely to retain its original discrete character, for there is a decided tendency for the papules to grow in size, until some are as large as a bean, and consequently they crowd one another for space. When two papules meet, they coalesce into one, and thus often patches are formed, of most irregular outline, corresponding to the angular edges of the outermost papules. Sometimes finger-like projections from the main patch will extend beyond its border, and almost always some discrete papules of the original type will be seen outlying. The waxy appearance of a patch thus formed is very characteristic, as is the violaceous color. Sooner or later, however, the waxy roof is apt to be replaced by a delicate layer of the whitest scales, glistening and very thin, but there is never the abundant desquamation seen in psoriasis.

Other localities than those mentioned may be first affected, or be attacked later, notably the sides of the neck, the penis, and the lower limbs. The disease is even sometimes found upon mucous membranes, where it generally takes the form of white spots or streaks. The face is usually free from the disease. Young adults are the most frequent sufferers. Sometimes the earliest papules, instead of being as small as the head of a pin, are larger, and rarely the papules are so thickly clustered from the first as to form practically one patch.

Lichen planus is usually, but not always, a symmetrical disease. It generally itches, and sometimes this symptom is a most annoying feature. Rarely, however, is the itching severe enough to cause the patient to lacerate his skin by scratching, as is the case with eczema.

The disease is a chronic one, but has an inherent tendency to recover in the course of a year or two. As it approaches a cure, the color of the patches becomes darker, the elevation is less marked, and eventually only a brown stain is left, which disappears slowly.

Upon the lower limbs, and occasionally elsewhere, one sometimes sees the phenomenon of the patches losing their distinctive characteristics and becoming verrucous.

Etiology.—The causes of this disease are shrouded in mystery. Usually it is seen in youth or middle age. Its symmetrical character, and its occasional linear arrangement, suggest a nervous origin. Digestive and uterine disturbances have, in individual cases, been assigned as causes. In the majority of cases, however, no cause can be determined.

Pathological Anatomy.—The pathological conditions found upon microscopical examination of individual papules may be summarized as a cellular infiltration into the corium, generally about a sweat duct, followed later by a marked thickening of the rete.

Diagnosis.—Lichen planus is liable to be confounded with eczema, psoriasis, or syphilis. From eczema it is distinguished by its sharp outline and angular configuration, by its color and the waxy appearance of its roof, and more especially by a study of the outlying papules. From psoriasis it differs in showing no tendency to clear up in the centre, in its location upon flexor instead of extensor surfaces, in its comparatively slight scaling, and in its color. From a superficial tubercular syphilide, which might be suggested by the general arrangement and color of a patch of lichen planus, the latter disease is to be distinguished by its failure to leave scars or to clear up in the centre, by its unresponsiveness to specific treatment, and by the absence of other signs of syphilis.

Treatment.—The treatment of lichen planus is very

unsatisfactory, since we do not know its cause. Any error of health, especially any nervous derangement, must receive especial attention. Digestive disturbances and

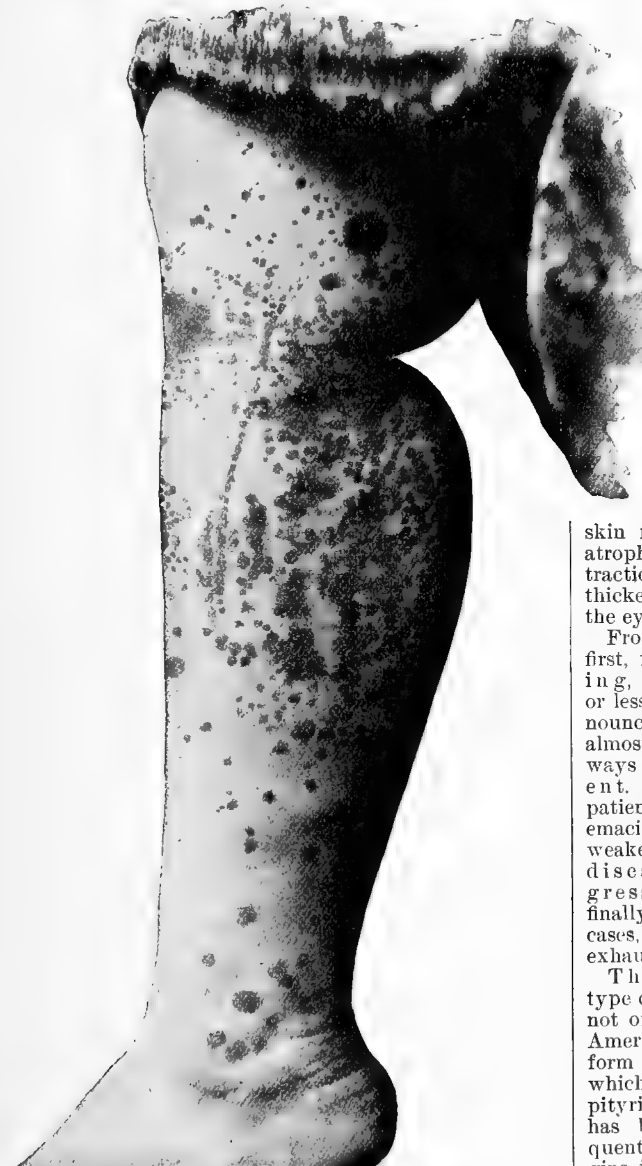


FIG. 3195.—Lichen Planus. (A. R. Robinson.)

sexual disorders should be set right. But these suggestions are equally applicable to the treatment of all diseases of the skin. In the beginning of lichen planus, when the disease is acute, alkaline diuretics, and soothing applications, such as lotio nigra, calamine lotion, and Lassar's paste, will modify its intensity. In chronic cases, arsenic, pushed to the limit of tolerance, and aided by stimulating applications, such as green soap, tar (10 to 20 per cent.), carbolic acid (5 per cent.), and bichloride of mercury (0.1 per cent.), will hasten the disappearance of the eruption.

LICHEN RUBER ACUMINATUS.—The second disease mentioned above, lichen ruber acuminatus, was first described by Hebra as a necessarily fatal affection. Further observation has established the fact that a milder form exists, which, while exceedingly chronic, may result in recovery.

A typical case begins with a profuse eruption of pinhead-sized papules, scattered quite generally over the entire body. Each papule is firm, and capped with a little epidermic plug of horny consistency, so that when the finger is passed over a surface thus affected the patch feels like a nutmeg grater. Each papule is pink or red in hue, and all are of about the same size. In some localities, such as the flexures of the joints, the abdomen, the sides of the neck, and the middle of the back, the papules are more thickly aggregated than elsewhere. The individual papules do not grow larger, but the eruption of similar papules continues, until in some places they are so crowded together as to give the impression of one broad lesion. When this condition is reached, the skin is much thickened, and, in places where there is much motion, as in the flexures of the joints, deep and painful fissures may form. Over such a patch, a peculiar desquamation finally occurs, thin, snow-white scales being gradually cast off and replaced by others.

Not all portions of the body undergo this characteristic change, for in some places the thickening of the integument is the main feature, and the desquamation is not very noticeable. Upon the face and hands, the thickened skin finally seems to undergo absorption, leaving an atrophic condition behind, with a tendency toward contraction. Upon the palms and soles, the skin is greatly thickened. The integument now resembles parchment, the eyelids may be everted, the fingers bent like claws.

From the first, itching, more or less pronounced, is almost always present. The patient becomes emaciated and weakened as the disease progresses, and finally, in most cases, dies of exhaustion.

This severe type of lichen ruber is not often observed in America, but a milder form of the disease, which the French call pityriasis rubra pilaris, has been not infrequently seen. It begins in the same way as the severe form, but when it has reached the stage of agglomeration into patches, many of the individual papules located outside the main lesions become absorbed. Then the general surface presents a reddened, slightly scaly appearance, resembling that of chronic eczema, and this is especially noticeable upon the face and hands. Upon the trunk or limbs are one or several of the

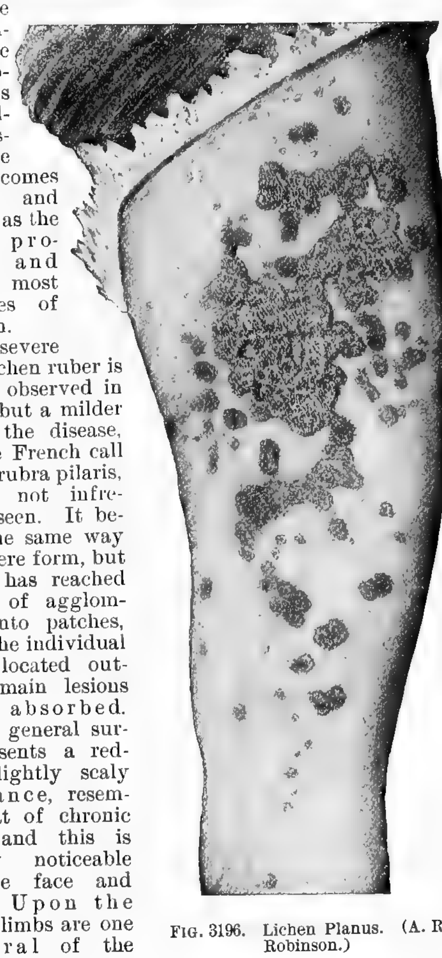


FIG. 3196. Lichen Planus. (A. R. Robinson.)

patches described above, thickened, rough, sharply outlined, and covered by papery, snow-white scales. The scales may eventually be cast off, and then the natural lines and furrows of the skin, vastly exaggerated, give the patch a markedly rugous appearance. The shape of these patches is sometimes grotesque, bands, angular lines, and stellar radiations projecting out from the main area.

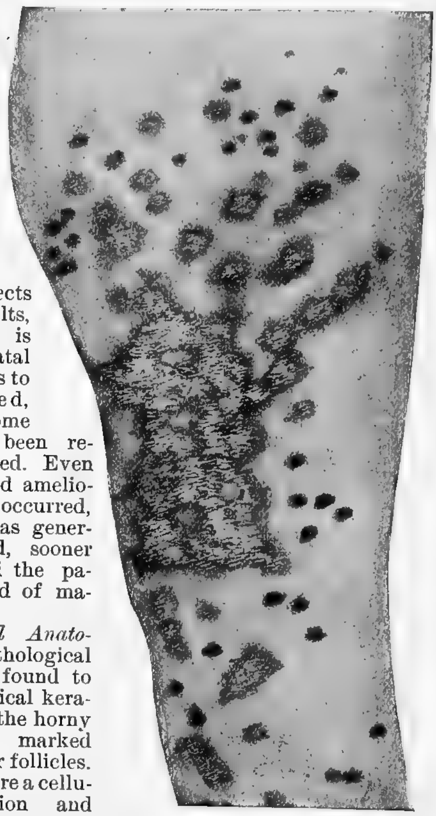


FIG. 3197.—Lichen Planus. (A. R. Robinson.)

Etiology.—The causation of lichen ruber, as of lichen planus, is unknown. It usually affects young adults, but no age is exempt. A fatal termination is to be expected, though some cases have been reported as cured. Even where marked amelioration has occurred, the disease has generally relapsed, sooner or later, and the patient has died of marasmus.

Pathological Anatomy.—The pathological condition is found to be a paratypical keratinization of the horny layer, most marked about the hair follicles. Later, there are a cellular infiltration and thickening of the rete.

Diagnosis.—The disease is sufficiently characteristic to prevent its being confounded with other affections, if its history is borne in mind. Yet in certain stages it might be mistaken for eczema, psoriasis, or lichen planus.

The condition of the hands and face, when the disease has lasted a long time, is very similar to that seen in chronic eczema. But the presence of horny papules on other parts of the body, and often the existence of thickened patches covered with thin white scales, will suggest the diagnosis.

From psoriasis the squamous patches may be differentiated by the less marked scaling, the absence of an annular arrangement, the failure to clear up in the centre, the avoidance of the usual sites of predilection, and the recognition of horn-capped papules outside the main patches.

Lichen planus differs from lichen ruber in its flat-topped, angular papules, its waxy sheen, its violaceous color, its limited area, and its tendency to get well.

Treatment.—When the exceedingly chronic nature of this disease is remembered, and its tendency toward a fatal termination, it will be seen that the treatment is very unsatisfactory. The best chance for recovery lies in arsenic, which should be pushed to the point of producing slight symptoms of poisoning, and should be continued for a long time. Crocker thinks that pityriasis rubra pilaris, which has been considered in this article as synonymous with the milder forms of lichen ruber acuminatus, should never be treated with arsenic, but does well under pilocarpine. Tonics, and a mode of life calculated to improve the general condition, are indispensable adjuncts to the treatment. Externally, for the generalized eruption, alkaline baths (such as bicarbonate of soda, five ounces to thirty gallons of water); for the patches, oil of Cade (10 to 20 per cent.), pyrogallic acid (10 per cent.), and ammoniated mercury (10 per cent.) are advised. The illustrations accompanying this article are from the collection of Prof. A. R. Robinson, of New York.
R. A. McDonnell.

LICHEN SCROFULOSORUM.—(Synonyms: Acne cachecticorum (Hebra, Kaposi), acne scrofulosorum [Colcott Fox], folliculitis scrofulosorum [Unna].)

SYMPTOMATOLOGY.—Hebra's original description is one of the few classics in dermatology which have stood the test of time. It runs somewhat as follows. The eruption consists of small, acuminate papules, varying in size from a point which is barely visible to an object the size of a pin's head. They are a bright red in color at first, fading gradually until they differ very little from the surrounding skin in tint. Slight pigmentation is generally left after their disappearance. A minute scale forms on the summit of each papule during involution, the desquamation becoming more prominent as the end approaches. The papules occur in groups, circles, or segments of circles, with little tendency to coalescence. This grouping is due to their localization about the lanugo hair follicles. The life of each papule varies from a few weeks to five or six months, but the tendency to relapse makes the duration of the disease most uncertain. The site of election is the lower part of the trunk, especially along the flanks, spreading from them in rare cases over the whole body on to the neck, the thighs, and upper arms. As a rule, progress is arrested at the axillæ and groins. There are no subjective symptoms.

Complications may change the appearance of the skin somewhat. The papules show occasionally a central comedo, which may become pustular, as in true acne. These lesions, which have been known to appear on the face, constitute what has been called the acne of cachectic infants. The skin may show evidence of malnutrition in the form of branny scaling between the papules, punctate follicular hemorrhage, and an eczematoid dermatitis, usually pustular, about the genitals. Not infrequently there is an acroasphyxia. In young children the disease may occur on the limbs without attacking the body. Involvement of the extremities is much more common than in adults, but pustulation, on the other hand, is less frequent.

ETIOLOGY.—Lichen scrofulosorum is a disease of youth; the youngest recorded case was in a child of eleven months, the oldest in a person of thirty years. Males, at least in German lands which furnish by far the largest number of cases, are more subject to it than females. The chief point in its etiology is the relationship to tuberculosis. According to Austrian statistics, over ninety per cent. occur in the tuberculous. Pulmonary disease is not so common a complication as the condition called scrofulosis, evidenced chiefly by lymphadenitis, bone disease, and tuberculous ulcerations of the skin (scrofuloderma). At times no such lesion is discoverable and there is no family history of tuberculosis.

Of recent years much has been written of this and kindred affections, such as erythema induratum scrofulosorum, and the controversy over their etiology has been more or less bitter, not to say personal. One party holds that the appearance of the papules is caused by circulating toxins; the other, that the tubercle bacillus is directly responsible. No one has the hardihood to deny the connection with tuberculosis. Out of a large number of animal inoculations with the tissue, only three have been reported as successful. Jacobi (Congress of German Dermatological Societies, 1892, p. 69) is the only writer who has found the tubercle bacillus in the lesion; Darier, Michelson, and Sack have failed after diligent search. Pelizarri thinks, in spite of his single success in inoculation, that the positive findings indicate only a contamination in a soil prepared by the toxins. Hallopeau

in 1892 announced that injection of tuberculin produced a perifollicular lesion resembling the lichen, and Schwenninger and Buzzi (*Monatshefte f. prakt. Derm.*, vol. xi., 1890, p. 581) have confirmed his observation. Jadassohn and the Vienna school, Kaposi at the head, are convinced that the disease is non-bacillary.

HISTOPATHOLOGY.—The lesion is a perifollicular, productive tuberculosis. The cutis shows an irregular formation of miliary tubercle, consisting of exuded elements in the shape of lymphocytes and plasma cells, epithelioid cells derived from fibroblasts and endothelium, and giant cells of the Langhans type with peripherally arranged nuclei. Coagulation necrosis and caseation are common. The new tissue is non-vascular. There may be made out, at times, even in areas of caseation, a delicate reticulum formed of the remains of the elastic fibres. Epithelial changes are secondary. The epidermis loses its interpapillary projections and becomes flattened. It may be slightly thickened and the horny layer may be lost or be partly detached in the form of a scale.

DIAGNOSIS.—Kaposi characteristically put this matter in a nutshell when he said that the diagnostic points were Hebra's original description and its occurrence in the tuberculous. Papular eczema is not limited to the trunk, as is often the case in lichen; in children the lesions are apt to become vesicular; they are of a deeper red and larger, and itching is intense. Follicular syphiloderms may be localized in much the same way as lichen of the scrofulous, but the papules are larger and involve the cutis more deeply. The common type occurs early in the course of syphilis, and careful search will show evidence of other "secondaries"—lymphadenitis, generalized and indurated, mucous patches, alopecia, etc.

Punctate psoriasis is much more generally distributed than the lichen, it occurs on the face and head, its tint is fiery red at the time of its first appearance, and the scales are thick, white, glistening, and moderately adherent. The papules of lichen do not enlarge; the guttate lesions of psoriasis do. In lichen or keratosis pilaris, while the site may be the same, the extensor surfaces of the upper arms and thighs are almost certain to be affected. The hair is surrounded by a horny plug, which is separated with difficulty.

TREATMENT.—Cod-liver oil, externally by inunction and internally, is the only remedy now recommended, because it is perfectly efficacious. It is thoroughly rubbed in and covered with oiled silk. The application is of course objectionable on account of the odor, and if it is impossible to secure the patient's consent, substitutes must be tried. The emulsions all have a slight smell, which becomes more pronounced in contact with the body. In case the repugnance is unconquerable, sweet oil, lanolin, or vaseline may be used in its place, pure or combined with one per cent. of thymol, menthol, or tar in the form of pix liquida or oil of cade. The general health requires close attention in every instance.

PROGNOSIS is good as regards the individual attack. Otherwise the outlook is that of the intercurrent tuberculosis which is not influenced by the cutaneous outbreak. If the tuberculosis continues, there is always danger of relapse. *James C. Johnston.*

LIFE INSURANCE EXAMINATIONS.—Life insurance examinations are made by physicians to determine the fitness of applicants for insurance. The purpose of the procedure is to estimate the expectation of life. It consists in obtaining a complete personal and family record and a knowledge of the present physical and mental condition of the subject. Formerly a certain number of impaired lives, roughly estimated at fifteen per cent., were declined and denied the benefits of insurance. Recently a few companies, revolutionizing the medical aspect of insurance by the ingenious co-operation of the actuary and medical departments, have devised plans for insuring these lives on a sub-standard basis, thus offering forms of insurance to all, or nearly all, in accordance with the expectation of life, and after a careful consideration of the age, occupation, history, and extent of impairment.

The Examiner and His Duties.—The mortality in insurance depends so largely upon the moral character and sound medical judgment of the examiner that the selection of one qualified to discharge these obligations should be most carefully made. He need not be the physician with the largest practice in the community and should not be selected through favoritism. A well-trained hospital graduate, conscientious and willing, will often give the greatest satisfaction. A pleasing personality, promptness as regards keeping of appointments and response to correspondence from the home office, interest, frank expression of opinion, courage of conviction, a kindly feeling toward agents, and a courteous, business-like approach and handling of applicants are requisites to success in the field of life insurance. With the introduction of sub-standard writing the examiner is no longer obliged to decline risks for insurance. In reporting impaired or sub-standard risks the duty of the examiner is merely to state clearly the facts, give full details of family or personal history, and explicitly the extent of the applicant's personal impairment; for the responsibility devolves upon the home office for classification or declination. The qualifications of standard risks—that is, normal lives—are as rigid as ever, and examiners are advised, when they consider an applicant a standard risk to state so clearly, avoiding unnecessary restrictions or otherwise interfering with the home-office estimation. If one will fancy himself in the home office trying to fathom incomplete and unscientific statements, he will readily see how much business may be lost to companies through these causes and from necessary delays in correspondence.

The Applicant.—Experience alone will teach the examiner to appreciate the great difference between the applicant for life insurance and the patient. The latter, when consulting a physician, will willingly, patiently, and honestly disclose everything pertaining to his illness, laying bare all the facts known to him, so that he may be benefited by proper treatment and advice. In the case of an applicant, on the other hand, the physician is often treated with indifference or insult, he is looked upon with antagonism, as an ally of a great corporation, and in many instances the applicant will resort to fraud, to hiding facts, and otherwise making misstatements. The relation between the applicant for insurance and the examiner being then merely one of business, if the applicant can be brought to appreciate this relation many obstacles and difficulties may be removed from the path of the examiner. Applicants often determine not to take out insurance, even after they have signed an application blank and an appointment card. In such a case a few courteous introductory remarks and the expression of interest on the part of the examiner will often induce them to change their minds and submit to examination. Again, applicants will often refuse to sign an application blank until after the home office has expressed an opinion as to their eligibility, but they may be induced to sign by the examiner, who, with tact, may often accomplish what the agent, with all his well-known persistency and persuasion, has failed to do.

Appointments.—Appointments for examination are, as a rule, made by the agent at the request of the applicant and in accordance with his own convenience. The keeping of these is of great importance in large cities where competition is keen and where the business of the applicant will not allow the giving of much time to an insurance examination. The examiner may save himself a great deal of time and trouble by learning, after some experience, when he may or may not call upon applicants at times other than the appointed hours. Positive appointments must be kept in the cases of policemen, firemen, trainmen, bankers, brokers, builders, and those engaged in other exacting businesses. The examiner need not adhere so closely to the request of storekeepers, grocers, bakers, housewives, janitors, and others who have many hours daily during which they may be examined. He will also appreciate the fact that clerks, machinists, carpenters, tradesmen generally, and labor-

ers cannot be seen during the day; they can be examined only at night.

The Application.—The application should be in the hands of the examiner at the time of the examination. In large cities, where applicants are strangers to the examiner, the application serves as the only means of identification, which is effected by a comparison of the signature on the application and the one on the medical blank. This comparison is important, for, apart from the question of identification, the genuineness of the signature prevents legal complications in the event of the questionable death of the insured.

The Written Examination.—The written examination consists in describing as accurately as possible the applicant's personal and family history. The many points are herewith noted:

(1) Occupation. Occupation not only influences the examiner's estimation of the risk, but influences greatly the home office in the matter of acceptance, classification, or declination. The examiner should with care inquire into the duties of a given occupation, especially when the duties may possibly be hazardous. Take, for example, the "laborer." Digging in the street is a fairly healthy occupation, but if the man's work lay in caissons or subways the occupation would then be considered hazardous. The electrician who handles the telephone or low voltage wires is a desirable risk, while the danger to employees in power houses or subways of great street railway companies is greatly increased and makes them less desirable risks.

As regards the examiner's estimation, we may take the musician as an illustration. A cornetist may be expected to have a slight degree of emphysema, but if this is without râles the examiner will display conservative judgment by giving it little or no attention; if, however, such a condition were found in the violinist or pianist, it would be considered due to pathological causes and have a distinct bearing on longevity. In the case of a "liquor dealer," the examiner should learn the number of hours which he spends daily in the saloon and also the length of time which he devotes to the bar.

(2) Age. Relatively few of those who apply for life insurance before or during the period of puberty pass standard examinations. This is due no doubt to functional derangements, such as systolic murmurs at the apex or to the left of the sternum, at the base of the heart, albuminuria due probably to masturbation, or an hereditary predisposition to certain diseases. These often extend through the adolescent period and disappear or are outgrown by the age of maturity. Different ailments are met with more frequently and are more fatal during given periods or ages. For example, respiratory and acute abdominal diseases are encountered between the ages of twenty and thirty years; rheumatism, organic diseases of the heart, acute diseases of the chest, between the ages of forty and fifty years; urinary and degenerative diseases generally, apoplexy, and paralyses, between the ages of fifty and sixty years. The intermediate period —between thirty and forty years—constitutes that in which are found the most desirable lives from the point of view of the insurance examiner.

(3) General appearance. Careful observation of the general appearance will aid the examiner in arriving at a correct estimate of the risk. The facies of tuberculous disease, of cancer, or of renal or hepatic disease may be noted. Due consideration, however, must be allowed applicants of sedentary habits; the clerk, tailor, hatter, and dyer may not have the rugged appearance of the carpenter, mason, blacksmith, sailor, or laborer who is daily exposed to the elements. They are, however, as a rule, fairly desirable risks.

(4) Habits. Intemperance in the use of alcohol or addiction to drugs may readily be detected in the applicant's appearance, breath, pupils, actions, writing, pulse, gait, or urine, or by a tremulousness of the muscles, and in such case the applicant should receive the severest and most decisive action on the part of the examiner, especially so when the applicant is under the influence of the drug or of alcohol at the time of examination. The examiner must have no sympathy for the applicant, as excess in the use of alcohol or drugs presages and predisposes to rapid dissolution in the event of his contracting an acute disease.

(5) The family history. Many applicants cannot give accurate details of their family record. Care should be exercised, in filling out the blank for the cause of death, to avoid the use of terms, such as "cold," "heart failure," "childbirth," or "change of life." When the term "change of life" is used, the examiner must inquire whether mental or malignant disease (as cancer) existed. When the cause of death is given as "childbirth" and death had occurred within two weeks, it may be inferred to have been due to hemorrhage, septic, cardiac, or renal disease; if, however, three months or more had elapsed between delivery and death, careful questioning on the part of the examiner is imperative, for tuberculous disease so often follows childbirth. When the applicant is markedly over or under weight, a statement regarding the weight of each member of the family is desired.

(6) Personal history of the applicant. The examiner should give as accurate a pen picture as possible of past or present illnesses. Relatively few applicants will confess to syphilis, and, inasmuch as many apply when the manifestations are not noticeable, a diagnosis is most difficult. Care should be exercised in separating the simple, local chancroidal disease from constitutional syphilis. It is advisable for the examiner to obtain, when possible, a description of the initial sore, a statement in regard to the length of time between exposure and the appearance of the sore, details and order of occurrence of the symptoms which followed, the date when the final symptoms appeared and what they were, and an account of the treatment, how long it was continued, and what was the condition of health both during the treatment and subsequently. All these are of importance, as failure to report them impedes the home-office handling of the case.

When the applicant is deformed, lame, or maimed, an exact description is necessary. If deformity of the spine exists, an expression of opinion as to whether it is due to tuberculous disease or not, is desired. Where there is shortening of a limb, the amount should be stated and also the form of apparatus worn should be noted. In the event of diseases such as appendicitis and rheumatism, detail in the report is necessary. In appendicitis, for example, the examiner should note the number of attacks, symptoms, medical or surgical treatment, and result of treatment. A point of especial interest and importance to the home office is a statement whether the appendix had been removed or not. In the case of rheumatism one should state definitely whether it was acute or chronic, the number of attacks, the duration of each, the joints involved, the character of the pain, the amount of swelling, and the results of treatment. The examiner should always state specifically the result in case of any past illness; for example, in the event of absolute recovery, he should write "no ill effects." In many instances the examiner will describe ailments or findings which will not affect longevity. Here he may assist the home office by expression of opinion such as "of no import," "merely mentioned as noticeable," or "has no bearing on longevity."

Care should be taken not to use indefinite terms, such as "shortness of breath," "dropsy," "colic," "fits," "fainting spells" or "vertigo," or "spitting or raising of blood," without detail, as all are but symptoms of more or less serious conditions or diseases. The "shortness of breath" of asthma, which is distinctly a neurosis, with paroxysmal dyspnœa, due to narrowing of the bronchial lumen, must be differentiated from attacks which resemble it, but which are caused by mechanical obstruction to the passage of air, as by pressure, within the thorax, upon the trachea (goitre, aneurisms), and by the presence of growths or foreign bodies in the larynx. On the other hand, the shortness of breath may be associated with cardiac diseases, tuberculosis, pneumonia, bronchitis, emphysema, and renal disease. The term "dropsy" occurs in so many places in the statements of applicants for life

insurance that special care must be exercised in stating whether it is of renal, respiratory, gastro-intestinal, circulatory, hepatic, or splenic origin. In the case of "colic" it is important to note whether it is stomachic, intestinal, hepatic, renal, ovarian, or uterine, or that due to lead poisoning. Sex, occupation, history, position of pain, and examination of the urine are among the points of importance. The term "fits," as used in the examination blank, is meant to cover such cerebro-spinal neuroses as epilepsy in its several varieties, chorea, and hysteria; also the convulsive movements seen in the course of certain diseases, as in uræmia, renal colic—if the ureters are obstructed,—in tumors of the brain, wounds of the head, and diseases involving the skull.

"Spitting or raising of blood." The determining of the source and cause is at times one of the most difficult and important details which the life insurance examiner is expected to supply. The differentiation between true hæmoptysis, hemorrhage from the gums, nose, throat, or stomach, demands especial questioning and examination. The appearance of blood, spat or raised, during the course of a severe bronchitis, diseases of the heart, pneumonia, aneurism, or ulcer or cancer of the stomach, will try the examiner severely in arriving at a diagnosis. In many instances it is simply impossible to obtain a perfect history from the applicant, as owing to delicacy or fear he will not disclose the facts. An examination of the chest will often clear the diagnosis, though physical signs may be absent, the disease manifesting itself for the first time by the spitting or raising of blood. Examination of the sputum for detection of the tubercle bacilli may aid, though a single examination may not suffice. If the raising of blood is noted in the course of diseases of the heart or aneurism, or if it come from the gums, nose, or throat, the history and physical examination will suffice for recognition of the source. In the case of hæmatemesis, the presence of ulcer or cancer may be determined by the history, age of the individual, and physical examination.

"Vertigo," "fainting spells," and "dizziness" result from the simplest as well as from the gravest causes. The importance of detail will readily be understood when we remember that the condition is met with in simple eye strain or astigmatism as well as in fatal chronic renal disease. It is noted after sexual excesses, in neurasthenia, leukæmia, diseases of the external, middle, or internal ear, in stomachic or intestinal dyspepsia, in disorders of the liver, in neuroses such as migraine, and in the immoderate use of tobacco, tea (prepared improperly), coffee, or alcohol; and it occurs with greater severity in cases of tumor of the brain, of fatty heart, of cardio-vascular neuroses, and of arterio-sclerosis, as seen in the aged.

The Examination.—After he has furnished a thoroughly written report of the candidate's past history, the examiner is expected to make a complete physical examination. This examination should be conducted in a quiet place, and the applicant should be observed (for many reasons) while standing. The examiner is advised to go over every case in the same way, without reference to the amount of insurance applied for. The home office will readily detect bungling, half-hearted, and unscientific work on the part of the examiner, and it will not reflect to his credit. The first steps of the physical examination consist in obtaining the pulse while the applicant is seated and before he has been subjected to anything that is likely to excite the heart's action. The pulse will be found a valuable aid to the examiner in his diagnosis. Character, rhythm, and rate should be carefully observed, especially while the applicant is seated. If there is any irregularity of the pulse, without organic lesion, and the subject is apparently a normal person, he should be questioned as to overindulgence in alcohol, tea, coffee, or tobacco. The weight, as a rule, must be estimated, as scales are rarely at hand. Measurements of the chest and abdomen should be made over the shirt. The height is usually estimated by a tape from a mark on the wall, corresponding to the level of the applicant's head, to the floor; as an expedient, however, I would suggest the determination by tape of the difference between the applicant's and the examiner's known height on the wall. For example: Suppose the examiner's height is 6′ 0″, and that of the applicant 5′ 5″, the difference on the wall of seven inches would give the exact height, 5′ 5″.

Every physician has his own method of examining the chest. Experience in making examinations for life insurance in a large city has taught me to depend almost entirely upon the ear in examining the chest. I resort to percussion only after auscultation has revealed the existence of some abnormal condition of the chest. While examination of the lungs may be made through many thicknesses of underclothing I invariably request the applicant to turn up his shirt when it becomes necessary to examine the heart. This not only allows the application of the stethoscope but also permits inspection of the chest and abdomen, palpation, and percussion if necessary, and reveals the appearance of the skin (color and existence of skin disease). Few, if any, applicants will refuse to comply with the request to turn up their shirts if this is made at the end of the examination, while many will refuse if asked at the beginning. Tact is needed here as well as at other times. If the examiner proceeds carefully and cautiously the applicants will grant any reasonable demand.

The Physical Examination of the Chest. The physician may proceed, as is his custom, by auscultation of the entire chest. All cases in which râles are found—except those which are recognized as being of a chronic character, or those in which the râles accompany emphysema—should be re-examined within two weeks. Few, if any, conditions are met with more frequently than bronchitis. When there is found a localized change in the respiratory note, increased fremitus and voice sounds, associated with moist râles, the case must necessarily be looked upon with suspicion. When re-examination is necessary, the examiner should assure the applicant that it is the usual procedure. Tuberculosis of the lung is rarely met with by the examiner except in its incipiency, for those in the advanced stages seldom apply for insurance. The medical examiner should therefore always be on his guard against overlooking the first evidences of this disease. If he trusts to the physical examination alone, in deciding this question, he is likely to reject many applicants who do not deserve the stigma. This difficulty may be overcome in time by the use of methods employed in private practice—namely, the microscopic examination for the tubercle bacilli. If possible, one should make all re-examinations in the afternoon, preferably between five and six o'clock, especially in those cases in which tuberculosis is suspected. The examiner will find his clinical thermometer a valuable aid in these cases.

In a case of emphysema, it is desirable to state whether there are râles present or not. The condition is most often noted in bakers, confectioners, butchers, and musicians (wind instruments).

The Heart.—We must appreciate that the existence of a murmur does not necessarily indicate organic heart disease; also that lesions may exist without the constant production of a murmur, except that heard with diastole, at the base, which is constant. This depends entirely upon the heart muscle and the degree of compensation present. The blowing sound heard below the subclavian is of little importance; it is most often observed in the anæmic. Many of the soft-blowing systolic murmurs heard mostly over the base of the heart in the pulmonic area, and occasionally at the apex, are hæmic. Furthermore, in applicants over fifty years of age, when a harsh, whistling, systolic murmur is heard over the aortic area, it indicates, in a great majority of cases, atheroma of the aorta, not a disease of the valves. When reporting lesions of the heart, it is desirable to give as full an account as possible. Experience has shown that the expectation of life is not the same for the different varieties of heart disorder; that it varies greatly according to the valve involved and the extent of compensatory hypertrophy or dilatation. This may readily be indicated by using a chart such as that here shown. In this particular in-

stance, the findings, which are noted on the chart (Fig. 3198), are those of a case of mitral regurgitation with a moderate degree of hypertrophy.

After the examination, which should not require more than from fifteen to thirty minutes to complete (depending on the length of the medical blank and the skill of the examiner), lengthy discussion or expression of opinion as to the applicant's condition should be avoided. The simple statement, "I am unable to tell you what is the result of the examination until after the urine tests shall have been made," will make the applicant understand that the examiner is not ready to commit himself. Agents complain they have great trouble in placing substandard policies after examiners have told the applicants, before the examination of the urine, that they are physically perfect, for then they fully expect first-class policies.

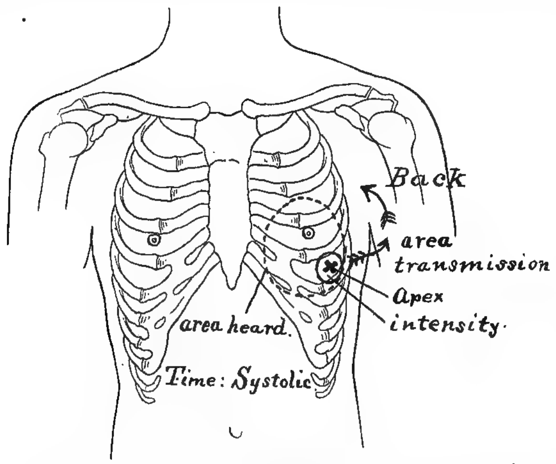


FIG. 3198.—Convenient Form of Chart for Recording Data relating to Heart Murmurs.

Examination of the Urine.—Under ordinary circumstances the only examination required in regular routine by the majority of life-insurance companies is the determination of the specific gravity, the reaction, and the presence or absence of albumin and of sugar. Some companies even omit the examination for sugar unless the specific gravity is suspiciously high. Microscopical examination is required variously by the different companies in ordinary routine, the requirement being determined either by the consideration of age of the subject or amount of insurance on the life. Such an examination, however, is ordinarily expected when from conditions peculiar to the case, such as the finding of albumin or of a sediment in the urine, it would naturally suggest itself.

Urinary examination other than the foregoing is at the discretion of the examiner or at the call of the insurance company, according to the circumstances of the case.

Methods, in the examination of urine for life insurance, are, of course, the same as in a corresponding examination for clinical inquiries, and for them the reader is referred to the article on *Urine*. The only special point in the ordinary routine examination for life insurance is that by the conditions of such examination the examiner is not expected to examine other than the sample of urine procurable at the time of examination. It would, of course, be desirable to examine from the collected urine of a day's voiding, but such procedure is ordinarily impracticable.

The urine should be obtained in a small wide-mouthed bottle, and it should be passed in every instance, if possible, in the presence of the examiner. An ingenious precaution against the mixing of specimens may be found in the use of bottles with ground glass fronts. The name may then be written on each bottle. Fraudulent substitution is possible, especially by women, owing to the privacy demanded in their case. The examiner should be suspicious of every individual, and if he cannot have the urine voided in his presence, he should endeavor in other ways to be certain that it has been passed by the applicant. He should grasp the bottle when handed to him in order to determine by the warmth whether it is fresh or not.

As the next step, he should note the color of the urine. In health this varies from a pale straw to a deep amber. It may be altered by the presence of bile or blood or by the ingestion of certain drugs as rhubarb, creosote, turpentine, etc. The urine of hysterical persons is pale. It is also light-colored in diabetes and after the ingestion of large quantities of water or beer. Various substances may give the freshly voided urine a turbid appearance. Among them may be mentioned mucus and epithelia, earthy phosphates of calcium and magnesium, the urates of calcium, magnesium, sodium, and potassium, and, finally, blood or pus. When urine has been allowed to stand for a certain length of time, it is apt to become turbid through the decomposition caused by bacteria. The phosphates, if amorphous, may be dissolved by the addition of nitric or acetic acid after the application of heat; but the heat may at first increase the opacity. Heat alone dissolves the urates. If the urine remains opaque after the application of heat and the addition of nitric acid, this fact indicates the presence of albumin and the microscope must be resorted to in order to determine the exact cause.

The specific gravity of normal urine varies from 1.015 to 1.025. The urinometer may be used with advantage after the analysis rather than before, so that the examiner may not in any wise be influenced by its reading. The specific gravity is increased in diabetes mellitus, in the first stage of acute fevers and of nephritis, and when blood is in the urine. It is decreased in chronic nephritis and in hysteria. In some instances I have found sugar in urine of which the specific gravity was as low as 1.010.

When first voided the urine of healthy persons is slightly acid. After it has stood for several hours, especially in warm or stormy weather, fermentation is likely to take place, thus rendering it unfit for examination. The odor is then ammoniacal, and the appearance is turbid. Filtration should be practised in every case of turbid urine to aid in rendering it clear; filtered urine should never, however, be saved for microscopical examination.

To determine the presence of the abnormal constituents, albumin and sugar, many methods have been devised. A few of the most simple and satisfactory are herewith described.

Albumin.—For the detection of albumin in urines of 1.015 specific gravity, or lower, the heat and acid test is the best. This may be performed as follows: Fill a small test tube one-half with clear urine, heat the upper one-third until it boils. If turbidity results, it is due to the presence of either earthy phosphates or albumin. If it is due to the former, it will disappear on the addition of a few drops of acetic or nitric acid. If, however, the turbidity does not disappear, but increases on the addition of acid, it denotes the presence of albumin. In urines of specific gravity of 1.015 or over the Heller or contact test will be found the most satisfactory. The method is as follows: Pour a small quantity of pure, colorless nitric acid into a small test tube, incline the tube and allow the urine to run slowly from a pipette (with a rubber bulb at one end) down on the acid, the urine overlying the acid. If albumin be present, there will appear at the line of contact a white band or zone. There may appear a zone of haziness, not at the point of contact, but higher, in the urine. This is composed either of mixed urates or of crystals of urea nitrate, which are dissipated by the application of heat to the urine; or it may consist of mucus, which is not affected by the application of heat. Resins ingested will produce a peculiar, dirty yellowish zone at the line of contact. This has none of the appearances of albumin and is dissolved by the addition of pure alcohol.

Sugar.—The two tests used for determining the pres-

ence of glucose are Fehling's and the phenyl hydrazin. Fehling's solution is prepared by dissolving 34.65 gm. pure crystallized sulphate of copper in 200 gm. distilled water; 173 gm. chemically pure crystallized neutral sodic tartrate are then dissolved in 480 gm. solution of caustic soda of specific gravity 1.14, and into this basic solution the copper solution is poured, a little at a time. The clear mixed fluid is diluted to 1,000 c.c., or the cupric sulphate may be dissolved in 500 c.c., the tartrate salt and potash solution being diluted to 500 c.c., and then the two solutions are to be kept in separate bottles to be used when a test is desired. The test is made as follows: Take 1 c.c. Fehling's solution, boil; if the solution remains clear add, drop by drop, urine from a pipette and heat; if sugar is present, a yellowish precipitate of copper suboxide will be thrown down, changing to a reddish-brown. Care must be taken not to mistake the flocculent deposit of earthy phosphates for the suboxide. Uric acid, when concentrated, gives a reaction somewhat similar to that of the earthy phosphates. These, however, have none of the characteristics of the suboxide reaction. The phenyl hydrazin test is somewhat more complicated and therefore not so well adapted for the present purposes. For a detailed account of this test the reader is referred to the article on *Urine*.

Microscopic Examination of Urinary Sediments.—When albumin is found in the urine the examiner must determine, by the microscope alone, the cause, as, in the classification of applicants, the albumininuria of nephritis, the pathological albuminuria, must be differentiated from the functional, accidental, or spurious albuminuria. The latter is due in many instances to the presence of semen, of blood, or of pus in the urine. Pathological albumin may be said to be due to (1) disturbances in the circulation; (2) changes in the composition of blood; (3) changes in the epithelia of the kidney. That the differentiation is important may readily be seen in the injustice which results from assigning to a simple or chronic cystitis (non-tuberculous), urethritis, etc., the same degree of objectionableness as to some form of actual renal disease. Examiners for life insurance companies, and especially those who live in the larger cities, would find it advantageous to possess a centrifuge, as haste is demanded in finishing and reporting cases. This is not the proper place for a discussion of the data by means of which this differentiation can be made. The reader will have to obtain this information in part from the article on the urine, and in part from the various articles which treat of diseases of the kidney, ureter, and bladder.

Abbott Smith Payn.

LIGATURES. See *Dressings, Surgical.*

LIGHT, THERAPEUTIC USES OF. See *Roentgen Ray, The Use of.*

LIGNOSULFIT is a brown liquid obtained as a by-product in Kellner's method of manufacturing cellulose. It consists of sulphurous acid and aromatic compounds which Simon says are those of the fir. For use in tuberculosis, a ten-per-cent. aqueous solution is allowed to saturate the air of a room in which the patient remains for from one to two hours a day. Simon reports decided improvement in the comfort of the patient and in the pulmonary signs.

W. A. Bastedo.

LILY OF THE VALLEY.—CONVALLARIA. "The rhizome and roots of *Convallaria majalis* L. (fam. *Liliaceæ*)" (U. S. P.). This familiar and favorite little flowering plant, a native of many parts of the northern hemisphere, and everywhere cultivated, has been on the list of medicines and in the pharmacopœias for generations, but had become about obsolete until a few years ago, when its diuretic power and its influence over the heart suggested its employment as a substitute for digitalis. Its flowers and rhizomes have both been used, and possess similar properties, but practice is now almost entirely confined to the latter, which is thus described by the Pharmacopœia: "Of horizontal growth and somewhat branched, about 3 mm. thick, cylindrical, wrinkled, whitish, marked with few circular scars; at the annulate joint with about eight or ten long, thin roots, fracture somewhat fibrous, white; odor peculiar, pleasant; taste sweetish, bitter, and somewhat acrid."

The peculiar constituents of lily of the valley are *convallarin*, a purging crystalline substance, and *convallamarin*, a bitter, half-crystalline whitish powder; both are glucosides, the former decomposing into convallaretin, and the latter into convallamaretin. Convallamarin is a rather active poison of the digitalis character, in small doses increasing the urine and strengthening the heart's action. Although less reliable and useful in cardiac weakness than digitalis, it is still worth remembering when that drug acts unkindly, or when, after taking it for a long time, it is desirable to change for a while.

Convallaria may be given in substance. Dose, about 1 gm. (gr. xv.), or one may prescribe, as is more commonly done, the same number of minims of the official fluid extract. The conditions which indicate the use of this remedy are the same as those which call for the employment of digitalis.

W. P. Bolles.

LILY, WATER. See *Nympheaceæ.*

LIMBS, ARTIFICIAL.—Artificial limbs are designed to take the place of the natural members when the latter are lacking either from congenital defect, or from surgical operation, or from traumatism. Deformities are corrected, and to some extent function is restored, by these appliances.

Lower Extremity.—The making of artificial limbs is a comparatively modern industry. Prior to the sixteenth century any one so unfortunate as to lose a limb had to depend upon the services of some ingenious friend or mechanic (carpenter or blacksmith) for such substitute as could be obtained. The productions of this period were for locomotion only, and made no pretence to conceal the loss of the limb. From this time to the end of the eighteenth century little progress was made; although in the writings of the celebrated Ambroise Paré (1509 to 1590) we find mention of an elaborate and ingenious leg, with joints at both knee and ankle; and, about a century later, the Dutch surgeon Verduin constructed an artificial leg for an amputation below the knee. This appliance consisted of a wooden foot connected by strips of steel to a copper socket lined with leather; this socket received the stump, and the weight of the body was supported, not on the flexed knee, but by lateral pressure on the stump and thigh. The productions of a Paré and a Verduin were for the few, not for the masses; and were heavy, intricate, and clumsy compared with modern appliances. At the beginning of the last century an impetus was given to the construction of artificial limbs by the Napoleonic wars; whatever claims to glory Napoleon may have, he certainly made many cripples and should be hailed as the patron saint of prosthetists. In the battle of Waterloo, the Earl of Uxbridge (afterwards Marquis of Anglesey) lost a leg, and a wooden one was made for him by Pott. This was the famous "Anglesey leg" which for a long time represented the highest prosthetic art, and was the pattern for many that followed; it was subsequently modified by Selpho and Palmer, and as such may be regarded as the "leg" on which the American prosthetic industry stands. The Anglesey leg consisted of a bucket or socket of wood to receive the stump, a steel joint for the knee, and a wooden joint for the ankle; this latter was moved by a spiral spring anteriorly, and by catgut cords posteriorly.

The Civil War may be taken as the starting-point of the modern prosthetic industry. The countless mutilations suffered at this time, and the liberality of the United States Government in providing the sufferers with artificial limbs, have brought out the ingenuity of several American prosthetists, and it is no exaggeration to say that in this branch of industry the Americans lead the world. But peace and the arts of civilization, such as the steam engine, the electric motor, the factory and

agricultural implements continue to manufacture cripples quite as rapidly as war ever did.

To give an account of every improvement and peculiarity claimed by the various manufacturers of artificial limbs in this country would be to fill many pages with reprints from their catalogues; the space at the writer's disposal will allow only a brief mention of some of the chief features with which he is acquainted; there may be others just as good, and better. The Anglesey leg is practically the model from which all subsequent attempts are derived. It was introduced into America by Selpho, who, later on, improved it by making the knee-joint of two broad steel plates, the upper one convex, the lower concave and covered with leather; it had india-rubber buffers to prevent concussion at the ankle joint. The Palmer leg had an excentric hinge at the knee to prevent sudden flexion, and wooden joints with spiral springs to straighten them after flexion. Dr. Bly further modified the "Anglesey leg" by making the ankle-joint without bolts or ordinary hinge; in their place he used a ball of glass or ivory which was inserted in a bed of rubber and by this means lateral as well as antero-posterior motion was obtained.

The ankle-joint is the *crux* with most manufacturers; here we find most variety, and here too are the strong and weak points of the various limbs. The "Marks" leg has no ankle-joint at all, and a foot of rubber with a wooden core. The "Frees" limbs, on the other hand, by means of an ingenious double joint at the ankle (duplex ankle joint), give both lateral and antero-posterior motion at that joint. Between these two extremes of universal motion and no joint at all there are many with antero-posterior motion only; and each variety has excellencies claimed for it. The "Doerflinger" leg has a steel-bearing rocker-plate ankle-joint without cords, and also a foot of felt. In Fuller's "walkeasy" leg there are ball-bearing knee-joints for amputation below the knee, and sponge rubber foot with articulated ankle-joint; Fuller furnishes three varieties of ankle-joint, as well as a sponge rubber foot with rigid ankle. The adjustable double slip socket of the "Winkley Artificial Limb Company" is designed to secure an artificial leg that does not chafe, rub, or pull on the end of the stump, or irritate or make sore the place of bearing. The "Chicago Artificial Limb Company" makes a leg with a ball-bearing ankle-joint, and a felt foot, which is lighter than wood or rubber, also an aluminum limb. Which of all these varieties of legs and ankle-joints is the best, we cannot undertake to decide.

The first real *artificial foot* was made about one hundred and fifty years ago by Ravatau. "This apparatus was intended for a dragoon whose right foot had been amputated above the ankle. The whole mechanism consisted of a boot which reached above the knee, where it could be fastened with leather straps; the boot was laced its entire length. In its interior a metal strip extended on each side from top to bottom, and at the end was attached to a hollow metal cylinder, which was intended to replace the missing ankle-joint. The boot had a metal sole. Inside of the cylinder was a coiled spring, with convolutions like a snail shell, forming a contour of the foot. Thus an elasticity was imparted in walking. The empty spaces in the inside of the boot were filled with horsehair. The dragoon by means of this contrivance was able to serve many years in the army." (*Scientific American*, Supplement, No. 1374.)

The Foot has presented grave difficulties to the prosthetists, who are almost unanimous in condemning the various foot amputations as being unsatisfactory from the point of view of their art. After Chopart's, Lisfranc's, and Hey's operations, as the extensor tendons have been divided, the heel is apt to be drawn up by the tendo Achillis. Of all the foot amputations Syme's presents the best possibilities to the makers of artificial limbs.

In the case of children, it is a most mistaken policy to wait till they have finished growing before supplying them with an artificial leg. Such a course of delay, as is often adopted, makes the child grow up round-shouldered and one-sided; and, to say nothing of the appearance, a properly fitting apparatus is more healthful. Self-lengthening limbs or extension apparatus can be procured from most makers; the "Chicago Artificial Limb Company" furnishes a self-lengthening limb, perfectly adjustable, and capable of being lengthened by the purchaser.

Upper Extremities.—Previous to the last century we find little mention of artificial arms and hands. We read of an iron arm made for a captain in the sixteenth century, and an iron hand weighing about three pounds with fingers that could be flexed by the other hand, and extended by pressing a knob on the side of the hand. But most of these early hands and arms were designed to enable the wearer to hold a sword or shield, or to handle the reins. A monk and a locksmith figure in the early manufacture of artificial hands, but their productions have only a historic interest. The first really useful hand was devised by Pierre Ballif, a dentist of Berlin, nearly a hundred years ago; most of the modern hands being simple modifications. As the need for artificial hands and arms is more urgent than is that for lower extremities, so the manufacture of the same seems more difficult; some prosthetists do not supply them at all, and some others supply them but do not make them. Artificial hands of delicate workmanship will enable a patient to write, use a knife and fork, raise and lift a glass, or shake hands; but where strength is required, as for laborers and mechanics, it is better to have a solid stock into which can be inserted the various implements required. Almost any tool or agricultural implement can be used efficiently; in some cases they are inserted into the hand, and in others they take the place of the hand. The attachments are generally by means of a screw or the "bayonet lock."

An artificial limb should be applied as soon as possible; that is, as soon as the wound is healed, and there is a good healthy stump. When amputation has been performed for disease a longer delay will be necessary than when traumatism has been the cause of the mutilation. As soon as healing is complete and there is no longer any tenderness, the stump should be prepared by daily bathing and massage, followed by bandaging. This will give a firm stump without superfluous adipose tissue. Joints should receive passive motion, not only to prevent ankylosis, but also lest the muscles by contracting should limit motion. In case of delay the stump is apt to become flabby and enlarged, and while in that condition is totally unfit for the application of an artificial limb. Ordinarily a limb can be applied in from one to three months.

With regard to the stump most suitable for the application of artificial limbs it may be said that, while the general rule in amputation has been to save all that is possible, this should be interpreted somewhat laxly with regard to the lower extremity. In the upper extremity any, even the smallest remaining, part of a hand is far more useful than any artificial appliance; but in the lower extremity the loss of an extra inch or two is of no moment compared with a serviceable stump. An artificial arm applied to the shoulder, and artificial fingers, have merely a cosmetic effect, and cannot be of much service. An artificial arm of considerable utility can be applied to a stump when the amputation has been made anywhere between the upper third of the humerus and the wrist. In the lower extremity, amputations at the hip do not allow of the application of a limb that can be of much use. In thigh amputations, a serviceable stump can be obtained anywhere between a point within five inches of the hip to one situated within about three inches from the knee. Amputations within three inches of the knee, either above or below the joint, should (from the prosthetist's point of view) be avoided.

Whenever possible the patient should be measured for and fitted with the artificial limb by the manufacturer. It is true that many makers are willing to have the physician or even the patient or some lay friend take the measurement, and they will send full directions for the purpose; but every effort should be made to have the

manufacturer himself assume this responsible task. An artificial limb is not a luxury, to be indulged in for a short time, but is meant to be a daily companion for many years, and if it is not comfortable and does not fit properly, it will never be of much use. To the writer it seems as rational to order an artificial limb from one's own measurements, as it would be to order a set of artificial teeth in the same manner; doubtless it *could* be done, but fortunately there are other and better ways.

In choosing an artificial limb, bear in mind the requirements of the patient; the weight and construction of the limb are more important than the price. As a rule, the simpler the apparatus the greater its utility. A complex piece of mechanism which cannot be got at without taking to pieces the whole limb, and which is liable to be constantly in need of attention, adds considerably to the cost, and in the case of a laborer keeps him from his work. Generally, it will be found best to obtain the catalogues of various makers in the vicinity, and, on selecting one, to be guided largely by his opinion. A reputable maker cannot afford to supply a poor limb, and as a rule he knows a great deal more about the matter than the average physician.

There is no reasonable limit to the possibilities of an artificial leg. Not only do patients stand, walk, and run on it, as well as attend to their daily avocations, but many also dance, skate, and ride a bicycle with apparently as much ease as before they were crippled. Without indorsing the glowing descriptions put forth by some makers, which almost make one think that their productions are vast improvements on the natural limbs, one cannot but recognize the truth of the following: "It is of no small advantage nowadays both to surgeon and to patients to realize that the loss of a limb is not necessarily a disfiguring or mutilating affair, but that very frequently an artificial limb well fitted will be of vastly more service and less trouble and annoyance than a member already crippled by disease, or left in a condition where life even is thereby threatened. In other words, the art of the instrument maker has done very much to assist the surgeon, and to make patients willing to undergo serious operations who otherwise would be very loath to lose so useful a part of their bodies as one or more limbs. It has done much also to atone for the horrible injuries and mutilations inflicted by railway and other accidents" (Truax, in "Johnson's Encyclopædia," 1894, v., 270).

The *weight* of an artificial limb is a matter of some importance. Legs vary from two or three pounds to seven or eight pounds. It is a mistake to buy one that is too light. One must bear in mind the weight, occupation, age, sex, and stature of the patient. Other things being equal, a heavy leg lasts longer than a light one. Some patients prefer a fairly heavy limb, others a lighter one. As a rule, it is well to have a leg sufficiently heavy to bear *more* than any strain that is likely to be put upon it. Beyond this we would have the leg as light as possible. It must be noted that it is the weight of the *foot* which makes an apparently heavy limb.

The *cost* of an artificial limb varies according to the maker and the length of the limb. The present market price of a first-class leg, thigh amputation, is from $80 to $125; below the knee, about $35 to $75; foot, $30 to $50; arm and hand, above the elbow, $50 to $100; below the elbow, $40 to $75. These figures vary little if at all from those given in the former edition of the Reference Handbook; in reality they are cheaper, as the limbs of to-day are superior to those of a decade and a half ago.

Durability of artificial limbs. This, too, is variable. Some will last fifteen years or even longer, others, by the same maker, only three or four years; the difference depending mainly on the amount of care and attention bestowed upon the limb; much, too, depends on the habits and occupation of the wearer. From five to seven years may be taken as the average "life" of an artificial leg; an arm lasts ordinarily about twice as long. Alterations in the stump often necessitate, if not a new limb, some modification in the socket. Many limbs are cast aside, not because they are worn out but because the wearer wishes for a new one. The United States Government, with marked generosity, supplies its pensioners with new limbs every three years.

In giving a list of some of the manufacturers of artificial limbs we would borrow the cautious words of the writer on this subject in the former edition of the Reference Handbook: "The following list is given with some hesitation as it is of course only a partial one, and the writer does not wish to imply that there may not be better manufacturers in the country than these. But general practitioners have usually so slight a knowledge of this branch of industry that the following names of well-known and reputable manufacturers are given for their convenience": C. A. Frees, 853 Broadway, New York, and 106 Fifth Avenue, Chicago; A. A. Marks, 701 Broadway, New York; Daly & Co., Bible House, New York City; Sharp & Smith, 92 Wabash Avenue, Chicago; George R. Fuller Co., Rochester, N. Y.; The Doerflinger Artificial Limb Co., Milwaukee, Wis.; J. E. Hanger, 207 4½ Street, N. W., Washington, D. C.; The Chicago Artificial Limb Co., San Francisco, Cal.; William T. Simpson (successor to James A. Foster), Detroit, Mich.; The Duluth Artificial Limb Co., Duluth, Minn.; The Winkley Artificial Limb Co., Minneapolis, Minn.

R. J. E. Scott.

LIMPING, DIAGNOSTIC SIGNIFICANCE OF.—Among the first signs of hip disease is limping, which, in the early stage, may disappear entirely to return after an interval of days or weeks; it is present sometimes in the morning when the patient leaves his bed, and "wears off" after a brief period of activity; it breaks up the natural rhythm of walking in which equal time is given to the two feet. When he limps the patient leaves the well foot longer on the floor than the affected foot. He makes the well one give a more accented stroke as it hastens to relieve the affected limb from the weight of the body. The well limb hurries forward to take the blow of the descending body, and thus destroys the natural rhythm in which the two feet move alike and in equal time. The simplicity of the normal rhythm makes a slight deviation from it very noticeable, so that limping always receives early recognition and attention. But in the absence of all other signs and symptoms it may not be easy to say which foot is the affected one, a question which may be answered by noticing which foot strikes the floor the hardest and quickest blow in walking. The foot which does this is the well one. The patient unconsciously hastens the action of this foot in order to relieve the affected one from the blow of the weight of the body which accompanies walking. The rhythm of human locomotion has not received the attention to which it is entitled. Normal rhythm may be expressed as follows: One — two — one — two — one — two, and false rhythm thus: One—two——one—two——one—two.

Limping may be described as asymmetrical walking. In ordinary cases it depends less on a difference in the length of the limbs and on their deformed relation to the trunk than it does on a failure of the two limbs to make steps of equal length and in equal time. And much of the lameness which we see is preventable by learning to keep correct time in the motion of the feet. A perfectly well person can walk lame by simply giving more time to one foot than to the other, which may be demonstrated at once if the reader of this will lay down the book and walk across his room, violating in his steps the natural rhythm in which time is equally marked and letting one foot linger on the floor longer than the other at each step. And conversely, one who is really lame can lessen the appearance of being so by learning to observe the natural (one—two—one—two—one—two) rhythm of human locomotion. This precept has proved of especial value in hip disease.

Adoniram B. Judson.

LINDEN FLOWERS.—*Lime Flowers. Tilia Flowers.* The flowers of several species of *Tilia* (fam. *Tiliaceæ*). This article, though still extensively employed among

the common people of Europe, and to some extent in this country, is of so little medicinal importance that it may be dismissed with brief mention. It contains a very small amount of volatile oil, with gum, sugar, and a little tannin. It is very mildly antispasmodic and emollient, and, given in the form of a copious warm draught, becomes diaphoretic. *Henry H. Rusby.*

LINEVILLE MINERAL SPRINGS.—Wayne County, Iowa.

Post-Office.—Lineville Springs. Hotel.

These springs are located two and one-half miles southwest of Lineville, a thriving town of 1,000 inhabitants, on the southwestern branch of the Chicago, Rock Island and Pacific Railroad. The Mineral Springs Hotel is a large, convenient, and commodious structure, picturesquely situated amid the hills bordering the Grand River. The scenery is diversified and interesting, and the atmospheric conditions are of a salubrious and invigorating character. Everything has been done to render the house and surrounding grounds pleasant, comfortable, and homelike. The sanitary arrangements are excellent, and, with pure air and the presence of the mineral springs, with hot and cold water, the place offers many inducements to the seeker after health or recreation. The water is brought from a point 150 feet below the surface by means of pipes to the interior of the hotel. It is clear and sparkling, and very pleasant to the palate. The following analysis was made by Mr. A. E. Woodward, late assistant geologist of the State of Missouri:*

One United States Gallon Contains:

Solids.	Grains.
Silica	0.11
Alumina	.28
Calcium sulphate	1.90
Magnesium sulphate	3.18
Sodium sulphate	180.30
Potassium sulphate	1.74
Sodium chloride	15.07
Total	202.58

This is a valuable purgative water. It is useful in dropsical affections due to renal disorders. It has also produced excellent results in cases of chronic constipation, functional disturbances of the liver, certain cutaneous diseases, and other affections. *James K. Crook.*

LINSEED.—Linum. Flaxseed. "The seed of *Linum usitatissimum* L. (fam. *Linaceæ*)" (U. S. P.). The universally known and cultivated flax is a slender, blue-flowered annual, its bark contributing the extremely tough fibres from which linen is made. It is a native of the Old World, but has been in cultivation so long that its wild state is wholly unknown. There is no plant of which the proofs of its ancient use are so substantial; linen coverings are folded around Egyptian mummies more than twenty-five centuries old. It has also been found in the relics of the prehistoric Lake Dwellers of Switzerland. It is frequently mentioned in the Bible, and has been known from the earliest times of ancient Greece and Rome. The employment of the seeds is also of very ancient origin.

The plants being collected for their fibre, and dried, the seeds are combed off from them, and constitute the article under consideration. Since the plants are pulled up, considerable dirt is apt to get into the seed. This is increased by the seeds of many weeds, and these impurities are often very imperfectly winnowed out. In trade, the relative amount of this foreign matter is roughly estimated by shaking up the seeds in an inverted conical bag, which carries the impurities to the bottom, or tip of the cone. The character of this matter, furthermore, conveys to the expert an idea of the geographical source of the product.

The following is the official description of flaxseed: "About 4 or 5 mm. long, oblong-ovate, flattened, obliquely pointed at one end, brown, glossy, covered with a transparent, mucilaginous epithelium, which swells considerably in water; the embryo whitish or pale greenish, with two large, oily, plano-convex cotyledons, and a thin perisperm; inodorous; taste mucilaginous, oily and bitter. *Ground linseed* (linseed meal, or flaxseed meal), for medicinal purposes, should be recently prepared and free from unpleasant or rancid odor. When extracted with carbon disulphide, it should yield not less than twenty-five per cent. of fixed oil. The filtered infusion of ground linseed, prepared with boiling water and allowed to cool, has an insipid, mucilaginous taste, and should not be colored blue by iodine T.S. (absence of starch)." The British Pharmacopœia requires a yield of thirty per cent. of oil, and, as a matter of fact, nearly thirty-five per cent. should be yielded. There are about fifteen per cent. of gum, twenty-five per cent. of albuminous matter, a little resin, and a trace of amygdalin, which gives the bitter taste. The ash should not exceed five per cent. The chief adulterants are starch, and the use of a meal made from the ground cake left after the expression of the oil.

Uses.—Linseed is chiefly, if not entirely, used in medicine as the material of which poultices are made, for which, by its elasticity, its low conducting power for heat, and its retaining qualities for water, it is exceedingly well adapted. The addition of camphor, as a preservative and antiseptic, is common, and gives a stimulant tendency to the poultice. *Henry H. Rusby.*

LINSEED, OIL OF.—Oleum Lini. *Flaxseed Oil.* "A fixed oil expressed from linseed without the use of heat. A yellowish, or yellow, oily liquid, having a slight, peculiar odor, and a bland taste. When exposed to the air it gradually thickens, and acquires a strong odor and taste; and if spread, in a thin layer, on a glass plate, and allowed to stand in a warm place, it is gradually converted into a hard, transparent, resin-like mass (absence of *non-drying oils*).

"Specific gravity: 0.930 to 0.940 at 15° C. (59° F.).

"It does not congeal above −20° C. (−4° F.).

"Soluble in about 10 parts of absolute alcohol, and, in all proportions, in ether, chloroform, benzin, carbon disulphide, or oil of turpentine.

"It should not more than slightly redden blue litmus paper previously moistened with alcohol (limit of *free acid*).

"If 2 c.c. of the oil be shaken with 1 c.c. of fuming nitric acid and 1 c.c. of water, it should neither completely nor partially solidify, even after standing for one or two days (absence of *non-drying oils*).

"If 10 c.c. of the oil, contained in a small flask, be mixed with a solution of 3 gm. of potassium hydrate in 5 c.c. of water, then 5 c.c. of alcohol added, and the mixture heated for about five minutes on a water-bath, with occasional agitation, a dark-colored but clear and complete solution should be obtained.

"If this liquid be diluted with water to the measure of 50 c.c., then cooled, and shaken with 50 c.c. of ether, the clear, ethereal layer, after having separated, should not show a bluish fluorescence, and when carefully decanted and allowed to evaporate spontaneously should leave not more than a slight, and not oily, residue (absence of *paraffin oils*)" (U. S. P.).

This differs from most other fixed oils in its large percentage of albuminous matter, though this imparts no special medicinal properties. Rancidity and septic contamination should be guarded against. Its chief use in medicine is in the formation of the official *Linimentum Calcis*, Lime Liniment or Carron Oil, consisting of equal parts of this and lime water, a favorite application to burns, as is the oil itself. The oil is used upon an immense scale in the arts. *Henry H. Rusby.*

LINT.—A loose, soft, and fine mat or fabric of linen fibre, used as an application to wounds, to check hemorrhage by the mechanical action of the fibre, to serve as packing or padding and as an absorbent vehicle for the

* Geological Report of the Mineral Waters of Iowa, 1892, p. 127.

application of medicinal substances. The best is the "patent" or woven lint. It is a soft, loosely woven cloth, with a heavy flocculent nap on one side, beautifully bleached and clean, and so tender that it can be easily torn in either direction or pulled into woolly bits. Picked, scraped, and ravelled lints, made, as their names indicate, from old linen cloths, are now mostly of domestic employment, having been superseded in the hands of physicians by the lint just mentioned and the now beautifully prepared "absorbent cotton."

Very similar substances are *tow* and *oakum*. The former is the tangled fibres heckled out in the production of linen fibre. The latter is the former soaked in tar, and adds antiseptic to the mechanical properties of the tow. *Henry H. Rusby.*

LIPANIN.—A fatty compound formed by the addition of five or six per cent. of oleic acid to fine olive oil. It has been proposed by von Mering as a substitute for cod-liver oil. Its use was suggested by the theory of Buckheim that the beneficial action of cod-liver oil was due to the fatty acids it contained. The proposed substitute is more palatable and is easily retained by the weakest stomach, and, when it is desired to do so, it may be readily formed into an emulsion. The dose for children is one teaspoonful before meals; for adults, one tablespoonful. *Beaumont Small.*

LIPOGENESIS.—Under this heading we have to consider how the abnormal accumulation of fat in the tissues takes place, and we divide the subject into two heads: 1. Fatty Infiltration; 2. Fatty Degeneration.

1. *Fatty Infiltration.*—In this process the fat which is formed outside of the cells, elsewhere in the body, simply accumulates in the cells. These contain larger or smaller droplets of fat. In perfectly typical cases the remaining protoplasm of the cell shows no degeneration, although the pressure of the fat droplets may produce a passive atrophy in other cases. Fatty infiltration occurs under normal as well as pathological conditions. Abnormal fatty infiltration of cells can scarcely be distinguished morphologically from those involved in fatty degeneration.

There is another phase of fatty infiltration, as seen in the heart, pancreas, etc., in which the fat accumulates in the cells of the interstitial connective tissue in a manner identical with that in which the normal panniculus adiposus is formed. In such conditions the accumulated fat may cause a secondary pressure atrophy upon the heart muscle cells, or upon the gland cells, etc.

Fatty infiltration and fatty degeneration may take place simultaneously.

2. *Fatty Degeneration.*—In this condition also of abnormal accumulation of fat in the tissues, it has been assumed in the past that the fat is formed by a retrograde metamorphosis, or degeneration, of the proteid elements of the cell protoplasm, by which process the integrity and capacity of the cell are injured. The correctness of this assumption has lately been called in question. It involves in large measure the solution of the physiological problem whether normally the fat in the body is formed from proteids or from carbohydrates. Many experiments and arguments have been made to solve this question, but it does not yet appear to have been satisfactorily answered. We need to know the following in connection with the processes known as fat metamorphoses (fatty degenerations): What are these fats? Do they differ from the physiological fats? Whence are they derived? To a certain extent the pathological questions await the solution of the physiological questions, but the interdependence need not be necessarily complete; for even were it shown that physiologically fats are or are not produced from proteids, the contrary would still be possible under pathological conditions.

Schäfer makes the following statement in his "Physiology": "That fat is formed from proteid has been almost universally accepted by physiologists." This is a question which was for many years held to have been settled by the experiments of Pettenkofer and Voit. But this view has been strenuously attacked of late by Pflüger, Taylor, Athanasiu, and others. When we come into the domain of pathology the subject is still more nebulous. The current pathological teaching is that in fatty degeneration the proteids of the diseased cells become converted into fats. Virchow and Klebs are largely responsible for this. Taylor remarks that in general pathological literature no explanation or discussion of worth attends this statement, and that a serious error has been made in thus dismissing with an unequivocal statement one of the most fundamental problems of biology. To those who would pursue the matter further, I refer, for critical review of the entire subject, to Taylor, "Critical Summary of the Question of Fatty Degeneration," *American Journal of the Medical Sciences*, 1899, cxvii., 569, and *Journal of Experimental Medicine*, vol. iv., p. 399, 1899; and to the article by Athanasiu in Pflüger's *Archiv*, 1899, lxxiv.

Taylor, after his critical review of the subject, draws the following conclusions: "1. The formation of fats out of proteids physiologically has not been demonstrated or made probable. 2. A formation of fats out of proteids pathologically has not been demonstrated. On the contrary, the weight of evidence is against it and in favor of the conception of the so-called fatty metamorphosis as infiltrations or formations of fat from carbohydrates."

"This position is provisional, and not conclusive. No one pretends to-day that the formation of fat from proteids is impossible; it has simply not been demonstrated or even made plausible. Future work must confirm or reverse our present conclusions."

In fatty degeneration there is an accumulation of larger and smaller fat droplets in the cell, sometimes so slight as to be scarcely visible, sometimes so great as largely to replace the protoplasm, crowding the nucleus to one side. These strongly refractile fat droplets are not changed by dilute acetic acid, are soluble in ether (being thus distinguished from albuminous granular degeneration), and when fresh are stained black by osmic acid. Macroscopically, organs affected with marked fatty degeneration are usually larger and softer than normal, have a grayish-yellow color, or are mottled with yellowish streaks or patches, and the normal markings of cut surfaces are more or less obscured.

Fatty degeneration may be associated with, or may follow, albuminous degeneration, and may occur under similar conditions. In addition to its local occurrence, as a result of local disturbances of circulation in the vicinity of inflammations or in tumors, etc., it is apt to occur in the liver, heart muscle, and kidney in chronic exhausting diseases, and in conditions and diseases to which profound anæmia is incident, or as the result of the action of certain poisons, such as phosphorus, arsenic, etc.

Clarence Arthur McWilliams.

REFERENCES.

Delafield and Prudden's Pathology.
Schafer: Text-book of Physiology, vol. i., p. 934.
Taylor, as above.
Athanasiu, as above.

LIPOMA. See the APPENDIX.

LIQUEFACTION NECROSIS. See *Necrosis*.

LIQUORICE ROOT.—(Glycyrrhiza, U. S. P.; Glycyrrhizæ Radix, B. P.; Radix Liquiritiæ, Ph. G.; Reglisse, Codex.)

The dried root of *Glycyrrhiza glabra* L. (Spanish liquorice) and of *G. glandulifera* Waldstein and Kittaibel (Russian liquorice) (fam. *Leguminosæ*).

The liquorice plants are large perennial herbs, the different species either smooth or hairy. That first named grows principally in southern Europe, the second chiefly in southwestern Asia and adjacent Europe. Both are largely cultivated, the former much more extensively. The plant sends down a very long root, which is nearly vertical, but may have several smaller branches. From

the crown, just underneath the surface of the ground, a number of long horizontal rhizomes emanate. These, though frequently mixed with liquorice to increase the yield, are not suitable for use. They have, however, an important use for purposes of propagation.

Liquorice root, when first collected, is fleshy and juicy, and is largely employed in this condition. For commercial purposes the roots are thoroughly cleaned and dried rapidly to prevent moulding. The Russian variety has its outer bark removed.

There are great differences of opinion concerning the relative quality of the two varieties. The correct view probably is, that Spanish liquorice is sweeter, while Russian liquorice, when powdered, is lighter in color and of finer appearance. Russian liquorice is rather more inclined to be free from bitterness, provided care be taken to excise all black, knotty, decayed pieces. If these be allowed to remain, even to a slight extent, they impart a marked bitterness to the powder.

Description.—*Spanish Liquorice.*—In long, cylindrical pieces, from 5 to 15 mm. ($\frac{1}{5}$ to $\frac{3}{5}$ in.) thick, longitudinally wrinkled, externally grayish-brown to dark brown, warty; internally tawny-yellow; pliable, tough; fracture coarsely fibrous; bark rather thick; wood porous, but dense, in narrow wedges; medullary rays linear; taste sweet, very slightly acrid.

The underground stem, which is often present, has the same appearance, but contains a thin pith.

Russian Liquorice occurs in large, usually crooked pieces, often several feet in length and 5 cm. (2 in.) in thickness, deprived of the outer bark, pale yellow without, internally of a lighter yellow than the Spanish and softer and of lower specific gravity, its cellular elements larger, its taste less sweet, and the wood frequently cleft. Any blackened, knotty, bitter portions should be removed before using.

Composition.—The most important principle is its peculiar sweet substance, *glycyrrhizin*, an amorphous, yellow, intensely sweet powder, soluble in hot water, but not in cold without the addition of an alkali. It is a glucoside, and may be resolved, by boiling with dilute hydrochloric acid, into an uncrystallizable sugar, and an amorphous, bitter substance, *glycyrrhetin*. It is said to be present in the root combined with calcium. Proportion about six per cent. There are also some sugar, three per cent. of asparagin, a variable amount of glycyramarin, a little resin and starch.

Action.—Liquorice has no physiological action beyond that of being slightly laxative. It is, like other sugars and syrups, soothing to the mucous membrane of the fauces, and hence much employed in coughs by itself, or as a vehicle or ingredient of cough mixtures. Syrups of liquorice and the ammoniated glycyrrhizin have been extensively used as vehicles to cover the bitter taste of quinine, which they do in an imperfect manner. The ammoniated glycyrrhizin may be rubbed up with the quinine in powder, or the quinine may be mixed with a syrup of liquorice at the instant of taking.

Administration.—Several preparations are official. Fluid extract (*Extractum Glycyrrhizæ Fluidum*, U. S. P.), in which the liquorice is exhausted with diluted alcohol and ammonia, the latter to make the active principle more soluble. The pure extract (*Extractum Glycyrrhizæ Purum*, U. S. P., so called to distinguish it from the *Extractum Glycyrrhizæ*, or crude Italian stick liquorice), in which the drug is exhausted with water and ammonia, and the percolate evaporated to a semi-solid consistence. It is useful for pill masses and as a vehicle; it is also an ingredient in the compound mixture of liquorice (*Mistura Glycyrrhizæ Composita*, U. S. P.), or old Brown Mixture, in which paregoric and wine of antimony are the active ingredients. *Glycyrrhizinum Ammoniatum*, U. S. P. (ammoniated glycyrrhizin, mentioned above), is prepared by extracting the liquorice with ammoniated water, precipitating the sweet principle with sulphuric acid, washing, redissolving in ammonia and water, precipitating and dissolving again, until it is sufficiently pure. It is in dark brownish-red, shining, brittle scales, of a very sweet, liquorice-like taste, and no odor, soluble in water and alcohol. Compound liquorice powder (*Pulvis Glycyrrhizæ Compositus*) is, properly speaking, a preparation of senna. Besides these, should be mentioned the commercial "stick," or "black liquorice," formerly imported on a large scale from many of the countries and islands of the Mediterranean, now chiefly manufactured in this country. It is chiefly used by children as a confection, but is also in extensive demand for coughs, colds, and sore throats.

W. P. Bolles.

LISSNER'S MINERAL SPRING.—Lewis and Clark County, Montana.

Post-Office.—Helena. Hotels.

This spring is located in Helena, about three hundred yards from the International Hotel, at the corner of Main and State streets. The spring gushes from the foot of a granite mountain, three hundred feet high, at the rate of about 20,000 gallons a day. A qualitative analysis by Messrs. Thomas Price & Son, chemists, of San Francisco, showed the presence of the chlorides, carbonates, and sulphates of lime, magnesia, soda, and potash. It is free from organic or vegetable matter. The water is used commercially and is recommended for indigestion, constipation, liver, kidney, and bladder troubles. We are unable to classify the water in the absence of a complete qualitative analysis.

James K. Crook.

LITHÆMIA. See *Gout.*

LITHIO-PIPERAZINE is a combination of piperazine and lithium which is soluble in water and is used in gout and the uric-acid diathesis in dose of 0.3–1.0 gm. (gr. v.–xv.) three times a day.

W. A. Bastedo.

LITHIUM.—I. General Medicinal Properties of Compounds of Lithium.—As lithium is closely allied to potassium chemically, so its salts exert practically the same kind of physiological influence as the corresponding salts of potassium. The only substantial differences are, *first*, the purely chemical one, that basic lithia forms with *uric acid* a salt much more soluble than the corresponding potassic compound; and, *secondly*, that clinically, in lithæmia and gout, speedier relief seems sometimes to follow from medication with salts of lithium than with those of potassium. But since the results reported have followed the employment of the remedy with the preconceived idea that such results must follow from theory, the clinical superiority claimed for lithium should be received with caution. There is no doubt, however, that the lithic salts are at least as efficient as the potassic, but then they have the disadvantage of being more expensive.

II. The Compounds of Lithium Used in Medicine.—These are the *carbonate*, *citrate*, *bromide*, *benzoate*, and *salicylate*. The first two only will be considered in this place. For the others, see respectively *Bromides*, *Benzoic Acid*, and *Salicylic Acid*.

Normal Lithium Carbonate: Li_2CO_3. The salt is official in the United States Pharmacopœia as *Lithii Carbonas*, Lithium Carbonate. It is a light, white powder, permanent in the air, odorless, having an alkaline taste and an alkaline reaction. It dissolves in 80 parts of cold and 140 parts of boiling water, but is freely soluble in carbonic acid water. It is insoluble in alcohol. Lithium carbonate behaves in a general way like potassium carbonate, except that, because of its feeble solubility in water, it is not locally so irritant. As an alkali it is remarkably potent, because of its chemically low combining number, and hence great saturating power in the neutralization of acids. Its use so far has been mainly as a substitute for potassic alkaline preparations in internal medication in gout and lithiasis. It is given in doses of from 0.30 to 1 gm. (gr. v.–xv.), several times a day, best administered in some effervescing water, since it is freely soluble in such liquids.

Normal Lithium Citrate: $Li_3C_6H_5O_7$. The salt is official in the United States Pharmacopœia as *Lithii Citras*,

Lithium Citrate. It is a white powder, deliquescent on exposure to air, odorless, having a slightly cooling, faintly alkaline taste and a neutral reaction. It dissolves in 2 parts of cold water, and in 0.5 part of boiling water. In alcohol it is practically insoluble. It should be kept in well-stoppered bottles. Lithium citrate bears the same relation, in medicinal behavior, to the carbonate that potassium citrate does to potassium carbonate. It is pleasanter to the taste and more grateful to the stomach than the carbonate, but undergoes transformation to the carbonate after absorption into the blood. Constitutionally, therefore, it is the equivalent of the carbonate, and it is used internally in gout and uric-acid diathesis. The salt, it must be remembered, is not alkaline while under its own form, and hence would be useless as a local alkali for the direct neutralization of acid. Dose, from 0.65 to 2 gm. (gr. x.-xxx.), several times a day, in aqueous solution.

A pleasant way to administer the citrate is to prescribe the official preparation entitled *Lithii Citras Effervescens*, Effervescent Lithium Citrate. This preparation is a powder composed of the admixture, in dry powder, of 7 per cent. of lithium carbonate, 37 per cent. of citric acid, and 28 per cent., each, of sodium bicarbonate and sugar. On adding the powder to water the ingredients dissolve, whereupon the citric acid decomposes the carbonates with formation of lithium citrate and evolution of carbon dioxide gas in effervescence. The dose is a teaspoonful of the powder, to be taken in water and drunk during effervescence. *Edward Curtis.*

LITHIUM-DIURETIN. See *Uropherin.*

LITHOLAPAXY—(Rapid Lithotrity with Evacuation), λίθος and λάπαξις (evacuation).

This operation, which has superseded the old method of lithotrity, and which successfully disposes of stones that could formerly be dealt with only by lithotomy, has been before the world for twenty-four years.

In January, 1878, Prof. Henry J. Bigelow [1] published his first paper introducing this procedure to the medical profession, and it was at once enthusiastically adopted by the surgeons of all countries.

The writer's association with Professor Bigelow in this branch of surgery lends authority to the description of the operation which follows:

Before the year 1878 lithotrity was performed by short sittings (a few minutes each), with intervals of several days between them. The débris, more or less finely pulverized, was passed with the urine.

If the expulsive power of the bladder was good, the voidance of the fragments was usually successfully accomplished. When, however, the bladder had lost its power, or when, owing to some obstruction, it could not thoroughly empty itself, the discharge of the fragments after crushing was an extremely uncertain matter.

Moreover, in a certain proportion of cases, especially when the stone was a hard one, or when the bladder was much inflamed, the crushing was followed by serious symptoms, with marked increase of the bladder inflammation, which not only put a stop to further crushing, but frequently went on from bad to worse and ended fatally.

This aggravation of symptoms after lithotrity was ascribed largely to the irritation of the bladder wall by the instruments; and operators tried to avoid trouble by making the sittings short, and by extreme gentleness in manipulation.

Sir Henry Thompson, then the English authority upon the subject of lithotrity, had recently stated it as his opinion that a sitting should not be prolonged beyond two or three minutes, and that stones requiring more than three or four sittings for their removal were not advantageously within the province of lithotrity.

Prior to this year (1878) there had been various attempts to remove by suction portions of the débris after crushing, and Clover's apparatus, consisting of a catheter and bulb, was sometimes used to aid a bladder in freeing itself. Such efforts at evacuation were, however, regarded as introducing special dangers into the operation of lithotrity, and writers upon the subject were practically unanimous in thinking that any serious attempt in this direction should be dispensed with, if possible.

In 1875, Professor Bigelow, having devised a more thorough evacuator than those previously in use, tried the plan of operating by a long sitting under ether, with the object of crushing the stone and completely removing the fragments at one operation.

The success of the first cases so treated showed that the previous dread of instrumentation had been to a great degree groundless, and that the presence of sharp angular fragments in the bladder after an operation was a source of more serious danger than that consequent upon the prolonged and skilful use of instruments which resulted in the complete removal of the stone.

These cases showed that, contrary to previous belief, the thorough evacuation of a large stone at one sitting could be accomplished without special danger, and in consequence of this success Professor Bigelow went on to perfect the apparatus which he described in his paper, published in January, 1878, and which he has since that time still further improved, until it has reached the forms which will be described farther on.

The operation of litholapaxy may be divided into two acts: (1) The comminution of the stone; (2) the evacuation of the fragments. We will first consider the instruments concerned in pulverizing the stone.

Lithotrites.—As has been said, lithotritists were formerly possessed with the idea that the bladder was an extremely sensitive organ, prompt to resent any irritation from the use of instruments, and that, therefore, only small stones, not requiring a great amount of manipulation for their comminution, should be crushed.

This belief, together with their failure to recognize the full size of the urethra, led the operators of those days to use instruments smaller and less powerful than the conditions allow, and than those which are now readily and safely employed, when the size and consistence of the stone make their use desirable.

The lithotrite now to be described was devised by Professor Bigelow. The modifications in its form are designed to enable it to meet the needs of the new operation.

It is made in various sizes,* of which the larger are very strong, and, though rarely necessary, enable the operator to deal with larger and harder stones than could be disposed of with the smaller instruments.

The *handle*, which is of hard rubber, is egg-shaped, and gives a better hold with more power than could be attained with the old wheel. By giving a full grasp to the hand it is far more comfortable and less fatiguing in a long operation.

The *lock*. Immediately below the handle is a revolving cylinder cap, which is attached to the screw guard and closes the lock by a mere rotation with the fingers of the right hand while it is grasping the handle.

So far as I know, this is the only lithotrite in which the lock is constantly under the control of the right hand. This arrangement gives the surgeon the great advantage of being able to lock and unlock the instrument indefinitely, and even to complete the operation without disengaging the hold of either hand. It thus saves time and strength, and lends greater accuracy to the manipulations.

The *blades*. In the female blade the rim is low and sharp, while the floor, especially at the heel, is high. A fragment readily falling upon this blade is firmly held by the rim while it is crushed.

The male blade is provided with a series of alternating notches, which expel the débris at the sides and prevent impaction.

In most lithotrites the dust is seriously impacted in the heel of the instrument. This difficulty is here met by raising the floor at the heel, so that no dust can lodge there. A large spur in the heel of the male blade also

* These correspond to Nos. 25, 27, and 30 of the French catheter scale.

drives the débris through a corresponding slot in the female blade.

The instrument is thus self-clearing and does not clog, so that when once introduced it can be continuously operated as long as fragments can be found to crush. Also, when it is withdrawn the jaws are not held open with impacted fragments of stone to lacerate the urethra. A good-sized instrument, fairly shut, occupies no more room in the urethra than a smaller one which must be withdrawn while partly open to be cleared of its débris.

FIG. 3199.—Handle and Lock of Closed Lithotrite.

In a long operation this avoidance of the injury which would be caused to the urethra by the frequent withdrawal of a clogged instrument is a matter of the greatest importance.

The end of the female blade is bent over so as to offer a blunted extremity, which, as may be seen in Fig. 3202, slips along the roof of the urethra and is much less likely to injure it than was the sharp toe of the old lithotrites. This form does not interfere in the least with the catching of fragments in the jaws.

In the lithotrite that has been described the sharp rim upon the female blade is very efficient in holding the fragment which is being crushed. Occasionally, however, in spite of this, the stone constantly slips from between the blades. When this occurs the open lithotrite should be used.

This instrument adds to the usual sharp rim another even sharper at the edge of the opening which the male blade traverses. This arrangement of the fenestrated blade makes the operation much more agreeable to the surgeon. The fragment rarely slips, and as the blades approach each other the force required is constantly diminishing instead of increasing, as it does when the solid blade is used.

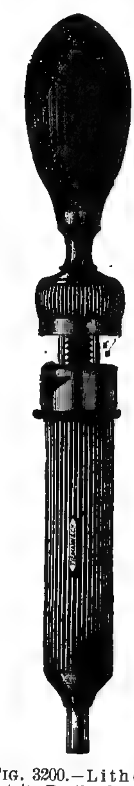


FIG. 3200.—Lithotrite Partly Open, showing the Cylinder Cap in connection with the Handle. The screw guard is seen as two rods alongside of the screw, reaching from the revolving cap to the cap of the lock. These slide through notches in the cap of the lock, and so connect it with the revolving cap that a twist of the latter turns the lock and so wedges up the screws.

The inner edge can be quite sharp, as it is prevented from ever coming in contact with the mucous membrane by the width of the broad and flat female blade. It is essential, however, that the male blade should pass absolutely through the female blade and occupy the same level at the outlet; for quite a small portion of the walls of the opening will sometimes so support a fragment not wholly extruded that it will cling to the instrument and be dragged out, and so lacerate the urethra.

EVACUATOR.—This instrument may be, in general, described as consisting of a tube, an elastic bulb, and a receptacle for the fragments.

Tube. For convenience of description the tube may be divided into two parts—the movable part, or catheter, and the fixed part, which enters the bulb and is attached to it by a bayonet joint.

Catheter. A straight tube offers the least possible resistance to the passage of fragments, and is therefore the best. A slight curve at the extremity sometimes facilitates the introduction of the tube in a difficult case.

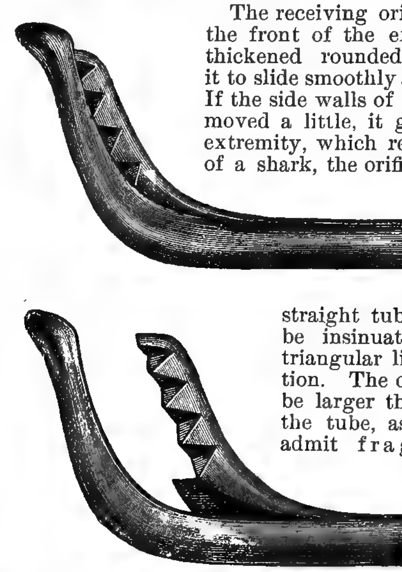


FIG. 3201.—Blades of Lithotrite, Open and Shut.

The receiving orifice should be on the front of the extremity, with a thickened rounded edge, to enable it to slide smoothly along the urethra. If the side walls of this orifice be removed a little, it gives a snout-like extremity, which resembles the head of a shark, the orifice occupying the position of the shark's mouth.

This form is advantageous; and in introducing such a straight tube the tip should be insinuated through the triangular ligament by rotation. The orifice should not be larger than the calibre of the tube, as it would then admit fragments which would be wedged higher up.

At the upper end of the catheter tube is a projecting wing, which facilitates the handling of the instrument. This wing is on the same side of the tube with the orifice, and is therefore a guide to its position.

The fixed portion of the tube connecting the catheter with the exhaust bottle extends obliquely upward to the centre of the bulb.

This tube is for convenience provided with a stopcock

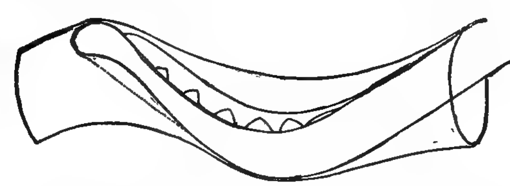


FIG. 3202.—Diagram showing the Blade of the Lithotrite in the Urethra, Illustrating the Advantage of the Blunted Extremity.

just outside of the bulb, and if a second cock is attached to the upper end of the catheter, the patient and bedclothing can be kept dry when coupling and uncoupling these tubes.

It is, however, the portion of this tube which is within the bulb that is of especial importance. This part, which is simply a prolongation of the catheter up into the bulb, is perforated all around with small holes, the aggregate area of which is larger than the opening at the end of the tube.

When suction is applied the fluid from the bladder, mixed with fragments, rushes up through this tube into the bulb. When pressure is now made, and the water is forced back to the bladder, the greater part of it goes through the perforations in the tube, which afford not only the shortest road, but by virtue of their great area also the largest and freest outlet.

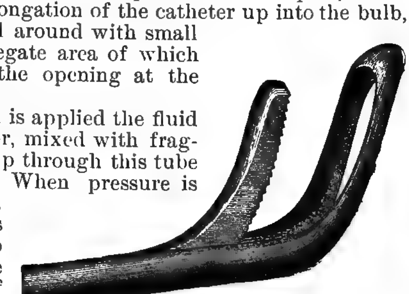


FIG. 3203.—Open-bladed Lithotrite, showing the Inner and Outer Edges of the Female Blade.

Thus the fragments enter the bulb easily, but are pre-

vented by the strainer action of this tube from returning to the bladder. The simplicity of this contrivance speaks for itself. There are no valves to get out of order, and if any mucus clogs the lateral holes it can be easily removed.

Fig. 3204.—Side View of the Extremities of a Curved and a Straight Tube.

The fragments which are thus caught and retained in the bulb naturally gravitate to the bottom of it, where they are received in the glass ball, or reservoir, which can be readily removed and emptied.

At the top of the bulb is an opening provided with a stopcock, to which a hose can be attached. Through this any air which finds its way into the apparatus can be at once expelled, and the amount of water in the bulb and bladder can be easily and quickly altered during evacuation without disconnecting the instrument—a matter of great importance, as an over-tense and a too-empty bladder are both to be avoided. One of the most important additions to the evacuator was the brace uniting the metal collar of the catheter with that of the glass receiver. This so steadies the catheter that it does not feel the movement of the bulb when compressed.

The Operation.—The presence of a stone having been established, a large steel sound may be passed down through the urethra to make sure that there is no stricture or other obstruction. If a stricture is found it may be rapidly dilated with large sounds, or divulsed. A narrow meatus may be cut.

The urine should then be drawn with a catheter, and enough boric-acid solution should be introduced gently to distend the bladder and so keep its walls out of harm's way during the crushing of the stone. From six to ten ounces is usually a proper quantity.

An elastic-rubber tube may then be tied lightly around the penis close to the corona glandis, to prevent the escape of water alongside of the instruments. This serves the double purpose of keeping a known quantity of water in the bladder and of preventing the wetting of the patient and bed.

Fig. 3205.—Extremities of Tubes, showing the Opening.

Before each introduction of an instrument the urethra should be filled with liquid vaseline, from a syringe, in order to lessen injurious friction as far as possible.

To introduce the lithotrite properly the point should be carried with considerable gentleness through the constriction made by the rubber tube, and it then slips without difficulty through the movable urethra. After the beak passes below the pubis the handle should be brought to a vertical position, and the instrument will then drop, almost without assistance, by its own weight, until the point rests just in front of the triangular ligament. Traction upon the penis now effaces the depression made by the extremity of the instrument in the bulbous urethra, and if the handle is then brought down gently between the thighs of the patient, and at the same time the point is advanced in the axis of the body, the instrument enters the bladder.

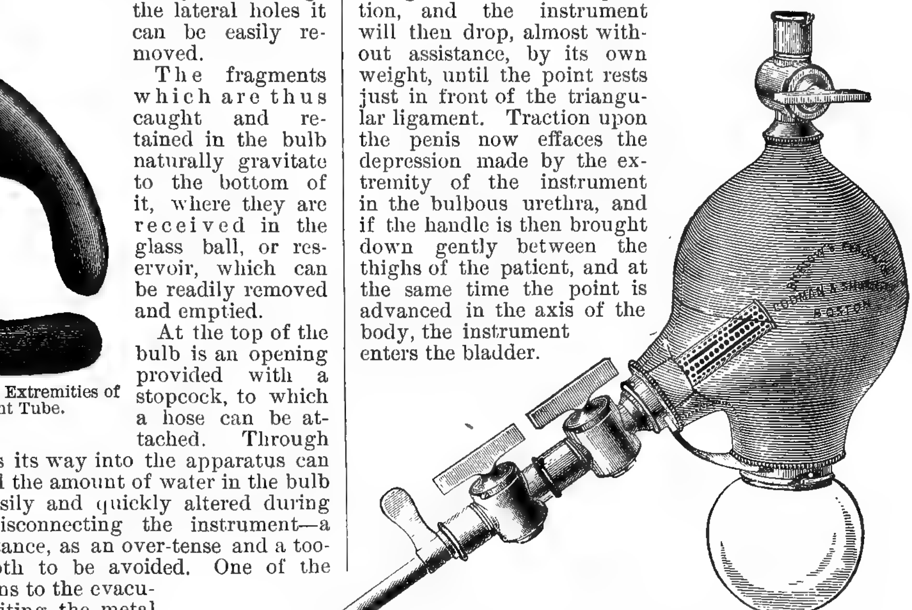


Fig. 3206.—Bigelow's Evacuator, with Evacuating Tube Attached, Ready for Use. It consists of an elastic bulb, with a glass receiver below and a stopcock at the top. Within the bulb, and open at the end, is a tube strainer to prevent the return of débris. To this tube, outside of the bulb, is attached a stopcock, which couples with another stopcock attached to the upper end of the catheter. Below there is a metal brace between the collar of the glass receiver and that of the catheter to steady the latter. The bulb forms a concentric handle to the catheter.

The places where difficulty may be met in a normal urethra are at the triangular ligament and at the prostate.

The point of the instrument may catch on the upper or lower edge of the comparatively rigid opening in the triangular ligament. If the handle is depressed before the beak of the instrument has been carried vertically down

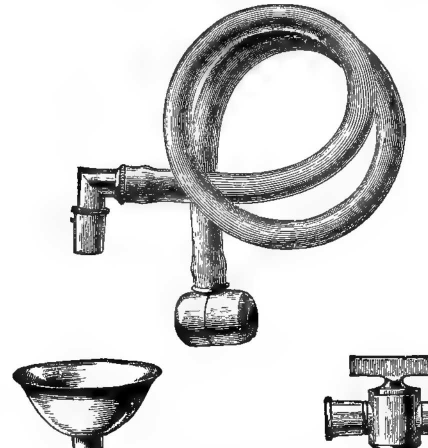


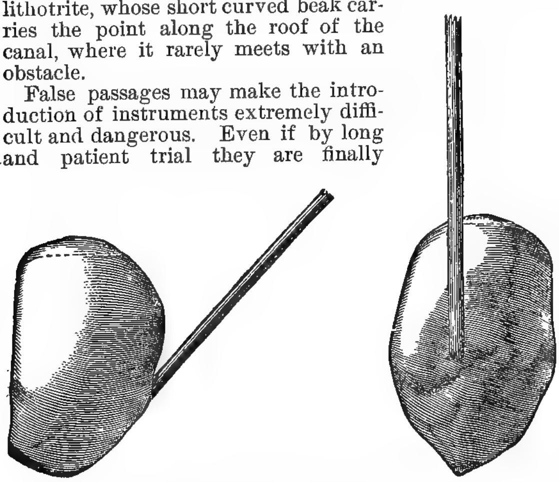
Fig. 3207.—Hose and Funnel to attach to Top of Bulb, and Stopcock for Upper End of Catheter.

as far as it will go toward the rectum, the point is likely to catch against the upper edge of this opening; while, on the other hand, if the instrument is pushed too forc-

ibly toward the sacrum, the lax, bulbous urethra is depressed below the aperture and the point catches on the lower margin. Practically, if the instrument catches at the triangular ligament it should be passed down with the beak hugging first the roof and then the floor of the urethra, and in one or other of these ways it will usually find its way through. The finger pressing against the convexity of the curve of the instrument in the perineum will often lift the point over the lower margin of the opening when it is catching there.

A similar difficulty may be met at the opening into the prostate. This happens but rarely, and is to be overcome by the same tactics. In case of much difficulty the finger introduced into the rectum serves as a good guide, and with it the point of the instrument may be lifted into the prostate when it is catching on the lower edge. An enlarged prostate is, as a rule, easily passed by the lithotrite, whose short curved beak carries the point along the roof of the canal, where it rarely meets with an obstacle.

False passages may make the introduction of instruments extremely difficult and dangerous. Even if by long and patient trial they are finally



FIGS. 3208 AND 3209.—Front and Side Views of a Plaster Cast of Bladder, with a Curved Tube Pressed Down into its Base.

passed, and the stone is comminuted and removed, the danger is not then over, for a serious swelling of the urethra, with retention of urine, is likely to follow, and under these circumstances the passage of a catheter is almost an impossibility.

To avoid this course of things, a catheter should, in such a case, be tied in at the end of the operation, and left in place until the urethra has, partly at least, recovered from the injury received.

A single false passage, if its position is accurately made out, may usually be avoided by carrying the instruments along the opposite wall of the urethra at that point. If, however, several of these pockets exist, in which the instruments are constantly caught, it will, perhaps, be a wiser plan to resort to lithotomy, which, though a more severe operation, has the great advantage of providing certain drainage for the bladder.

The stone and, subsequently, the fragments are found and seized upon the floor of the bladder. Figs. 3208 and 3209 show how, when the lithotrite stands at an angle of forty-five degrees with the axis of the body, the floor of the bladder is indented, so that the extremity of the instrument lies at the bottom of a funnel-shaped depression and fragments naturally gravitate into or close alongside of its jaws. Usually when the blades are opened in this position the stone falls between them. When this does not occur the blades should be opened in the upright position, and then turned over on one side or the other and closed along the floor of the bladder.

A stone may be too large to fall into the depression made by the instrument, and it may then be necessary to depress the handle before it can be seized. This sensation of having the stone above the sound or lithotrite sometimes leads to the belief that it is attached to the upper bladder wall when such is not the case.

The crushing of the stone should be done as thoroughly as possible at the first introduction of the lithotrite. This saves time and irritation to the urethra, and with the self-clearing instruments described above, much may be accomplished by a little patience and skill in searching for fragments.

The form of the female blade, with projecting end and width enough to carry its sharp rim away from close contact with the male blade, makes nipping of the bladder wall unlikely to occur. This accident is so serious that it should be further guarded against by always carrying the blades toward the centre of the bladder and slightly rotating, to make sure that they are free, before screwing down upon anything that has been seized.

The curved evacuating tubes are passed like catheters, much in the manner described for the introduction of the lithotrite.

The straight tube should be passed down toward the rectum as far as it will go, and then, being brought down to a horizontal position, it should be gently pushed up in the axis of the body. At the moment of bringing the tube down between the thighs, pressure should be made at the root of the penis to relax the suspensory ligament. Before advancing the instrument horizontally it is well to withdraw it very slightly, in order to disengage its point from the depression which it is likely to make in the bulbous urethra.

When there is a hitch at the triangular ligament, or at the prostate, the tube may usually be carried through by a rotation in the manner of a corkscrew.

When the tube has entered the bladder the bulb is connected with it, and on opening communication between them a gurgle will be heard, indicating the entrance into the bulb of the air contained in the tube. By means of the hose entering at the top of the bulb this air is expelled and its place supplied by water.

Some operators use evacuators which do not provide for the escape of this air, which is churned in and out of the bladder during the pumping, and is a source of some inconvenience.

In commencing evacuation the point of the tube should be held a little above the floor of the bladder. At every squeeze of the bulb the fragments are then thrown into commotion, and by the subsequent expansion are aspirated through the tube as they are flying about the bladder. If the opening were at first buried in the débris, it would be liable to be clogged by the fragments rushing in together and wedging. Later, when but little remains, the point of the tube should be carried to the bottom of the bladder to gather the remnants as they gravitate into the depression thus made.

The direction of the orifice of the tube should be occasionally changed, so that any side pockets may be thoroughly washed out. The pouch behind an enlarged prostate should be especially attended to in this way.

During the earlier part of the evacuation there should be no interval between the compression and expansion of the bulb. The object at this time is to set the fragments whirling and to catch them while suspended. Later, when the fragments are few and the tube is carried to the floor of the bladder, a few moments should elapse after compressing the bulb, to give the fragments time to settle into the depression about the end of the tube before the expansion which is to suck them into it, takes place.

When any particular aspiration brings fragments, the position of the tube should be kept unchanged until they cease to come.

The wedging of a fragment in the tube causes an obstruction which is very noticeable. The compression of the bulb is rendered difficult and its expansion is slow.

An angular fragment may lodge so that while it allows the passage of water, it prevents the entrance of other fragments. This condition may be suspected if there is a constant clicking against the tube and still nothing appears in the reservoir.

The usual point where fragments wedge is at the entrance to the tube. When one becomes thus fixed, it

may be dislodged with a stylet; and this is the safest method of disposing of it, although with care the tube may generally be drawn out with the fragment in it. This procedure, however, is not devoid of danger, for sharp projecting angles may lacerate the urethra, or the bit of stone may even remain sticking in the passage.

The tube may also be obstructed by the bladder wall, which is sometimes sucked into the orifice. The stoppage from this cause is usually not continuous, but the wall flapping against the opening gives a series of jerks to the instrument, which reminds one of the bite of a fish.

When this is felt the end of the tube should be moved to another part of the bladder, and if it then continues, it shows that the bladder is not sufficiently distended, and water should be added through the hose at the top of the bulb.

When for several minutes no fragments appear in the reservoir, the tube should be systematically moved about the bladder until every part has been explored. If no débris appears during this procedure, and there is no longer any clicking of fragments too large to pass, it may be concluded that the bladder is empty and the operation is completed.

Small particles of stone may be caught in folds and pockets of the bladder, and so may escape a thorough pumping. It is therefore wise before the patient passes from under observation to give another washing with the evacuator. This is of especial importance when an enlarged prostate or other obstruction to the flow of urine exists, as under these circumstances a fragment of stone if retained has little chance of being expelled by the natural efforts, and may serve as a nucleus for another calculus.

Strict aseptic precautions should be observed throughout the operation. The instruments should be thoroughly cleansed with a five-per-cent. solution of carbolic acid. The vaseline used for lubrication should be perfectly fresh, and may even contain a small quantity of eucalyptus oil as an additional precaution. The fluid used for the evacuator should have borax or boracic acid added to it, to sterilize it and to exert a soothing effect upon the bladder.

Size of Instruments.—A few words upon this subject may not be out of place, as much of the earliest and most persistent criticism of the operation was directed against the use of large instruments.

The advantage of using as large an evacuating tube as the urethra will readily admit is so evident as to need no argument.

Otis' measurements have shown that the average adult urethra has a calibre about 32 mm. in circumference, which corresponds with No. 32 of the French catheter scale. A tube one or two sizes smaller than a given urethra will usually pass with ease, and will give rise to no undue irritation.

The size of the lithotrite selected will depend largely upon the size and hardness of the stone. As the largest Bigelow lithotrite is No. 30 in the French scale, the operator will rarely be limited in his choice of instruments by the calibre of the urethra, except when this is unusually small.

A soft, small stone can be readily comminuted with a small lithotrite, and if the urethra is narrow it is, of course, an object not to pass larger instruments through it than are necessary. But if a large oxalate-of-lime or uric-acid calculus be found, its thorough reduction is greatly facilitated by the use of instruments strong enough easily to overcome the increased resistance.

Under these circumstances a large instrument works faster, more thoroughly, does not have to be introduced so often, and saves the strength of the surgeon.

This last point is of great importance, as the delicacy of hand so necessary in manipulations through the urethra is with difficulty maintained through a long operation, and yet it is even more necessary toward the close than it was in the beginning. *Arthur T. Cabot.*

[1] Am. Jour. Med. Sciences, January, 1878.

LITHOTOMY—(λιθοτομία, from λιθος, a stone, and τεμνειν, to cut) a cutting operation for the removal of a stone. This term is by usage applied merely to the removal of a stone from the bladder. When otherwise used, the different application is designated by a prefix (*e.g.*, nephrolithotomy).

Lithotomy is one of the oldest operations in surgery, and was formerly the only surgical procedure to be resorted to in cases of stone.

Early in the last century (1824) the crushing operation (lithotrity) was brought into recognized use by Civiale, and was widely adopted in the treatment of cases in which the stone was so small or so soft as to be easily pulverized.

In 1878, Bigelow introduced the operation of litholapaxy, and showed its applicability to stones of considerable size and hardness. So efficient has this operation proved itself that it leaves but a comparatively small number of cases to be treated by lithotomy.

For a brief discussion of the principles which should guide one to a decision between the crushing and the cutting operations in a given case, see under *Bladder*, page 799, of volume i. of this Handbook.

Suprapubic Lithotomy.—In the first half of the last century the infrapubic routes for reaching the bladder were the only ones in general use. The great fear of the peritoneum and the high mortality resulting from urinary infiltration in the tissues of low vitality in front of the bladder led surgeons to regard the suprapubic route as too dangerous for use except under very exceptional circumstances. With the advent of the modern methods of aseptic and antiseptic surgery the dangers largely disappeared and the great advantages of reaching the bladder by this method have brought it again into prominence. At the present time, it has practically displaced all other methods of lithotomy, and the perineal operations are used only when some indication other than the removal of stone exists.

The suprapubic route enables the operator to do his work under the guidance of the eye and makes it possible thoroughly to examine the bladder and to discover and treat other complicating conditions.

As litholapaxy successfully disposes of stones of large size, it is now necessary to resort to a cutting operation only when a very large calculus is so tightly grasped in a contracted bladder that the lithotrite cannot be manipulated about it, or when other exceptional conditions exist which interfere with the crushing of the stones or which make a thorough inspection of the bladder necessary.

Thus, for the conditions under which litholapaxy is not the best procedure, the suprapubic operation fulfils the indications better than any of the perineal incisions.

Operation.—The relation of the peritoneum to the anterior wall of the bladder is the important anatomical consideration in this operation. With the bladder in a collapsed condition, the lower fold of the peritoneum lies at or near the upper border of the symphysis pubis. As distention of the bladder takes place, this fold rises until, when the bladder contains fifteen or twenty ounces, a distance of three or four inches separates it from the pubis. This leaves an unobstructed space through which the bladder may be entered without danger of opening the peritoneum. The production of such extreme distention as this is, however, unwise; but, as will be shown, the peritoneum can be easily avoided in other ways. Moreover, if the peritoneal cavity is opened by accident during the preliminary steps of the operation, it can readily be closed by suture and there is little or no danger of infection entering the abdomen. It is, nevertheless, wise to take precautions to avoid opening the peritoneum and to make the closure tight should this accident occur.

Preparation for any cutting operation for the removal of stone should include an attempt to render the urine as aseptic as possible and, by the use of water and if necessary diuretics, to bring the urine up to a satisfactory quantity. The administration of urotropin in doses of five to seven grains three times a day will tend to inhibit

the growth of bacteria in the urine, and by thus rendering the urine less infectious will promote rapid healing of the wound. In a certain proportion of cases urotropin will prove an irritant to an ulcerated bladder. When this is the case, boric acid, benzoate of soda, or sandal oil may be substituted for it. The lower bowel should be emptied on the day before the operation by the use of cathartics and enemata.

The first step in the operation is the careful irrigation of the bladder with some aseptic or mildly antiseptic fluid, and for this purpose a four-per-cent. solution of boric acid is perhaps to be preferred, but sterile water or sterile salt solution will be satisfactory if other solutions be not at hand. Irrigation should be continued until the wash water returns clear, when a moderate amount of fluid should be left in the bladder for the purpose of distending it and raising the anterior fold of the peritoneum. The amount of fluid to be left in the bladder will depend largely upon the condition of that viscus. In the presence of chronic ulcerative processes, and especially in old men, the danger of rupture of the bladder is not unimportant and care should be used to avoid dangerous distention. In a state of partial anæsthesia spasm of the bladder may greatly increase the danger of rupture. The quantity of fluid usually well borne varies from seven to ten ounces and this amount should rarely be exceeded. The operation can be done with ease and safety without elevating the peritoneal fold at all, for the peritoneum can be readily identified during the dissection and pushed back with the finger. Rectal distention with the Peterson bag is now rarely resorted to. It is true that it increases the separation of the peritoneum from the pubis, but this object is also obtained by the Trendelenburg position without the increased danger of rupture of the bladder which accompanies the use of the rectal colypeurynter. The rectum itself has also been occasionally ruptured by too vigorous distention with the Peterson bag. With the patient, then, in the Trendelenburg position, the incision is made in the middle line above the pubis of a length varying from three to five inches according to the thickness of the abdominal wall. The lower end should come well down over the upper border of the symphysis. The fascia covering the recti muscles should be freely divided in the middle line and the muscles should be separated with some blunt instrument just above the pubis. The interlacing fibres of the pyramidales will be encountered and as they occasionally cross the middle line some of the fibres may have to be divided. The dissection is thus brought down to the deep fascia, which should be cautiously divided, exposing the properitoneal fat and the peritoneum itself. It is to be remembered that between the anterior peritoneal fold above referred to and the upper border of the pubic bone is a fibrous layer called the fascia propria of Velpeau, and it is wise, therefore, in all cases to make a transverse incision along the upper edge of the pubic bone which will divide this fascia and allow the peritoneum to be pushed back with ease to the upper angle of the wound where these tissues may be held by a retractor. The bladder wall is thus exposed over a considerable area.

In cases in which the operation must be done on an empty bladder, as where urethral or perineal fistulæ exist, it is well to pass a sound into the bladder so as to raise the wall on the point of the instrument and bring it readily into the wound. A guide suture may be placed on either side of the point where the bladder wall is to be opened to serve as a retractor and guide to the edges of the bladder wound in the later stages of the operation. As the bladder is opened the forefinger of the left hand is introduced through the aperture and the bladder thus explored and the size, position, and number of stones are ascertained. Stones of good size are most readily removed with the ordinary stone forceps. Small stones, especially when multiple, require a lithotomy scoop aided by irrigation for their removal.

The opening in the bladder wall should be made of a size sufficiently large to allow of the easy extraction of the stone. The peritoneum is easily stripped back off the apex of the bladder when it is necessary to enlarge the incision in that direction. A clean-cut wound of large size may be sutured and will heal readily, whereas a smaller wound, the edges of which have been bruised by the extraction of a stone too large to pass readily, will often give much trouble by sloughing.

It is occasionally found better to break up a very large stone before extraction.

When the bladder is sacculated the possibility of there being a stone hidden in some of the pockets should not be forgotten. Occasionally such a pocket is found with a stone in it which is larger than the orifice. In such a case every effort to enlarge the orifice by gradual dilatation should be made before the knife is used, on account of the fear of urinary infiltration if the bladder wall is cut.

No operation for stone should be considered finished until the bladder has been carefully examined to see if any other pathological process exists. It has happened to the author to find a little myomatous tumor of the bladder wall which, being slightly ulcerated, had been acting as the forming place for a succession of recurring stones. This tendency to the recurrence of stone entirely disappeared after the removal of the tumor.

When the operation is finished, the question of the closure of the bladder wound is a matter of considerable importance. The ideal procedure is to close the bladder wound tightly and the abdominal wall over it and to rely on the constant drainage of an in-lying catheter to prevent an accumulation of urine sufficient to force its way through the stitches. This technique is applicable to but a comparatively small number of cases—viz., in which the bladder is in good condition,—and is more likely to be successful in comparatively young patients. A safer procedure is to close the bladder wall tightly and leave the abdominal wound partially open, thus forestalling the possible occurrence of infiltration between the bladder and the abdominal wall. Where doubt exists as to the wisdom of completely closing the bladder, drainage should always be instituted, as the complications resulting from failure to drain are far more serious than the inconvenience which may be caused by establishing a suprapubic drainage. One or two drainage tubes should be introduced down to the base of the bladder and the bladder wall then closed tightly around them. If, in this closure of the bladder wound, the sutures are placed at a little distance from the edge of the wound so as to roll in the edges, it will be found that these inverted edges will act as a valve when the drainage is removed and that more rapid closure of the sinus is thus insured. Stitches placed in the bladder wall should not perforate the mucous membrane, as they act as nuclei for future stone formation. When suprapubic drainage alone is relied upon, two tubes should be used in order to provide for through-and-through irrigation. If, however, the bladder is tolerably free from blood and mucus, a single tube combined with an in-lying catheter accomplishes the same object extremely well.

The incision in the abdominal wall should be closed as in other surgical operations, either in layers or with through-and-through sutures, according to the preference of the operator.

Some authors lay much stress upon the firm attachment of the opening in the bladder to the layers of the abdominal wall, and they believe that with this precaution infection of the fatty tissue in the space of Retzius is less likely to occur. This firm attachment of the bladder wall to the abdominal parietes tends to limit the distention and subsequent mobility of the bladder, and we are inclined to think that the placing of a small amount of gauze between the bladder wound and the properitoneal fat layer will be a sufficient safeguard against infection. It is very rarely necessary to leave gauze drainage in the bladder after uncomplicated suprapubic lithotomy, the only indication for such drainage being the presence of considerable hemorrhage, which ought not to occur except in very rare instances.

After-Treatment.—The tubes which provide for drain-

Lithotomy.

age of the bladder should be connected with tubing long enough to conduct the urine over the side of the bed into some receptacle. If snug closure of the bladder wall about the tube has been accomplished, there will be but little leakage and the dressing remains comparatively dry. The latter should be large and absorbent to hold what urine does escape and should be changed as often as necessary to keep the patient dry.

Irrigation of the bladder is usually a necessary part of the after-treatment. In cases in which there is but little cystitis, a daily flushing of the tubes is usually sufficient to keep them free from clots of mucus. Where there is any tendency to hemorrhage, or when much cystitis exists, more frequent washings are necessary to remove the clots which tend to clog the tubes.

The advantages of through-and-through drainage, either through two tubes or through a catheter and tube, are obvious.

When the urine has become clear and the prevesical wound has begun to granulate, the time has come for removal of the tubes.

When two suprapubic tubes are in use, one should be removed first and a catheter may then be placed in the urethra. If now all goes well, the other tube may be removed a few days later, and, with the urine draining away through the in-lying catheter, the suprapubic wound will soon close.

If the bladder wound has been sutured in the manner earlier described, so as to roll the edges inward, the removal of the tubes will be quickly followed by closure of the sinus. Where a large opening in the bladder has been made and only partially sutured, or where sloughing has taken place around the edges of the bladder wound, the closure of the opening may be a very tedious matter. Complete closure may be expected, unless there be obstruction to the outflow of urine through the natural passages. In the presence of urethral obstruction from prostatic enlargement or other cause, great persistence of the abdominal sinus is to be expected, and, unless measures are taken to remove the cause of obstruction, it may be impossible completely and permanently to close the opening.

Complications.—The most serious complication in this operation is infection and infiltration of urine into the cellular tissues of the prevesical space. With careful technique, this accident should occur rarely and then only in debilitated patients. Its prevention will depend upon the avoidance of tearing, crushing, or otherwise mutilating these tissues of low vitality, and the more quickly, carefully, and smoothly the operation can be done the greater will be the probability of escaping this serious complication. It is also wise when dealing with a foul urine from a chronic cystitis to wall off the prevesical space with gauze during the operation and to guard against a later infection by packing around the tubes with gauze at the end of the operation. If infection and infiltration of urine occur, free drainage of any collections of pus is of the first importance.

Another occasional and at times serious complication is excessive sloughing in the region of the wound. This is most commonly seen in patients of much lowered vitality, and at times the slow extension of this process may assume alarming proportions. Its treatment will consist in supporting the patient's general strength, insuring adequate drainage of the bladder, and avoiding any infection of fresh areas by attempts to remove the sloughing tissues before they are properly separated. The dressing should be conducted with great care and delicacy, and too great zeal should not be shown in removing the partially necrotic tissues. Hemorrhage will occasionally occur in cases in which there has been marked ulceration of the bladder wall. When moderate in amount and especially when coming from the prostate or prostatic urethra, it may be satisfactorily dealt with by the administration of ergot and frequent irrigation of the bladder. When it assumes more alarming proportions, it may be necessary to pack or tampon the bladder after the manner of controlling hemorrhage in suprapubic prostatectomy. This will, however, be very rarely necessary in suprapubic operations undertaken solely for the removal of stone.

Prognosis.—The prognosis of suprapubic lithotomy will depend entirely upon the condition of the patient. In uncomplicated cases, with patients in good condition, the mortality should be entirely trivial, but in old debilitated subjects, with disabled kidneys, the mortality is likely to be considerable. Frisch reports 400 cases with a mortality of 12.7 per cent., while Guyon's mortality during the last ten years has been 28 per cent. This mortality should be compared with Frisch's death rate with litholapaxy during the same period, which was 2.6 per cent. These figures cannot be taken at their full value in a comparison of the two methods; for the more complicated cases are the ones selected for lithotomy, while the simpler cases are treated by litholapaxy.

In spite of this, however, Frisch's percentages compare very closely with those obtained by a study of large collections of cases in which the operation selected is practised in practically all the cases of stone coming to the reporting surgeon.

The tendency to recurrence of stone is not essentially different whether lithotomy or litholapaxy be done.

Lithotomy may, therefore, be wisely reserved for those cases to which litholapaxy is not applicable or in which the importance of inspection of the bladder outweighs the additional danger.

Infrapubic Lithotomy.—The bladder may be opened below the pubis by the use of either the so-called lateral or the median perineal route. Neither of these operations is to-day held on a par with the suprapubic method and only a very brief description of them will be given.

Lateral Lithotomy.—In this operation, after moderate distention of the bladder, the patient is placed in the so-called lithotomy position and a grooved staff introduced into the urethra. This staff should be made to touch the stone if possible in order that the operator may be sure of its presence. The staff is then entrusted to the care of an assistant, who holds it vertically, so that its point is just within the bladder, and keeps it strictly in the middle line. The scrotum is held up out of the way and the knife is entered in the middle line at a point an inch to an inch and a half in front of the anus, and then an incision is made downward and outward two and one-half to three inches over the ischiatic fossa. The incision is carried down rapidly through the loose fat and underlying tissues until the membranous urethra is reached. The staff is felt, the knife is introduced into the groove, and both staff and knife are then pushed forward into the bladder. The knife having entered the bladder the handle is depressed, carried to the operator's right, and the blade in the bladder makes the incision of the desired length in the left lateral lobe of the prostate. The knife is withdrawn, the left forefinger introduced along the staff into the bladder, the staff is withdrawn and stone forceps are substituted. Stones of large size may have to be broken up before they can be extracted, and care must be used not to leave fragments in the bladder at the end of the operation.

This operation is superior to the median perineal operation next to be described in that it gives more room for the extraction of stones.

Median Perineal Lithotomy.—An incision is made on the raphe, the urethra is opened as in all perineal operations in the membranous portion, and the incision in the prostate is made downward in the middle line.

The space afforded by this incision is so limited that only small stones can be removed through it.

The operation is applicable especially to cases in which the stones are impacted in the urethral orifice so that they are partly in the bladder and partly in the prostatic urethra. It may also be used for the removal of small foreign bodies from the bladder.

In case a stone is found too large for safe removal through the median incision, perineal litholapaxy may be practised. The short route to the bladder makes this an easy and efficient operation.

Arthur T. Cabot.
Hugh Cabot.

LITTEN'S SIGN. See *Chest, Physical Examination of.*

LITTON SELTZER SPRINGS.—Sonoma County, California.

POST-OFFICE.—Healdsburg. Hotel and cottages.

These excellent seltzer and soda springs are located about four miles north of Healdsburg, on the line of the San Francisco and Northern Pacific Railroad. The springs and adjoining property—about 1,000 acres—have been incorporated, and extensive buildings, in the way of hotels, cottages, bath-houses, etc., are contemplated. Some of the waters are used commercially. The water is slightly acid when first drawn, but by exposure it loses its carbonic anhydride and becomes alkaline. The following analysis was made some years ago by Dr. Winslow Anderson:

ONE UNITED STATES GALLON CONTAINS:

Solids.	Grains.
Sodium chloride	79.34
Sodium bicarbonate	6.26
Sodium carbonate	72.73
Potassium carbonate	3.60
Magnesium bicarbonate	13.90
Magnesium sulphate	6.75
Calcium bicarbonate	14.05
Calcium sulphate	5.03
Ferrous carbonate	2.14
Alumina	6.81
Borates	4.43
Lithia	Trace.
Ammonia	.33
Silica	8.09
Organic matter	Trace.
Total solids	223.46
Free carbonic-acid gas	375.60
Temperature, 62° F.	

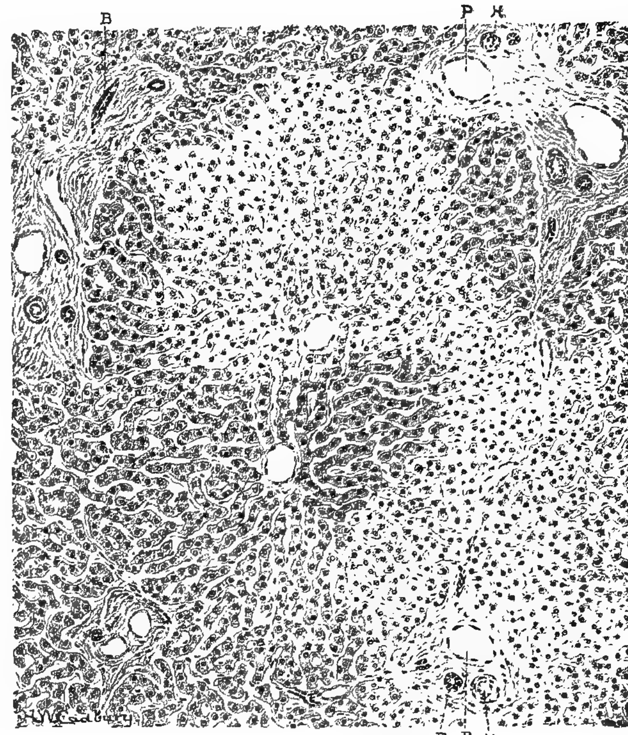


FIG. 3211.—Section of Liver. × 80. *P*, Portal vein; *H*, hepatic artery; *B*, bile duct. (Hendrickson.)

A previous analysis by Professor Hanks showed 228.69 grains in solids and 383.75 grains in carbonic anhydride to the United States gallon. The temperature of the water is 62° F. It is much used as an antacid in dyspepsia, and in uric-acid states. The water has aperient and diuretic properties. *James K. Crook.*

LIVER, ANATOMY OF THE.—The liver is the most bulky of the abdominal viscera and the largest gland in the body. Its size and its connection with the portal system render it at once remarkable. In the abdominal cavity it occupies the greater portion of the right hypochondriac, a large portion of the epigastric, and a small part of the left hypochondriac regions. Although the shape of the liver is somewhat variable because of pressure of neighboring organs, still it has in general a wedge-like form with the base to the right.

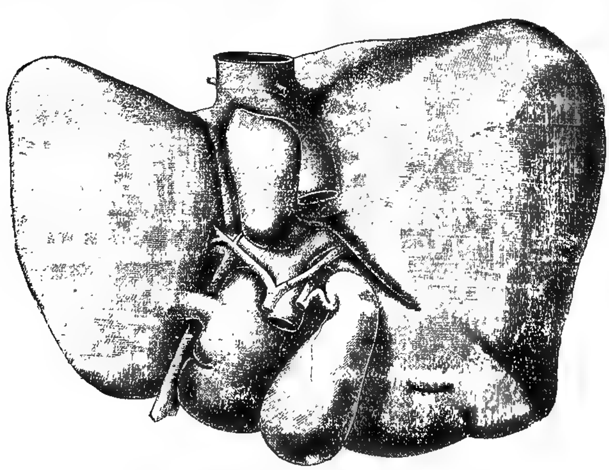


FIG. 3210.—Inferior Surface of the Liver. (Sappey.)

Because of the irregularity of the liver's contour some difference has existed in the descriptions of the surfaces. We may, however, regard it as possessing five: anterior, posterior, superior, inferior, and right surfaces.

The anterior surface, the largest of all the surfaces, is smooth and triangular and composed of the right and left lobes; the line of demarcation between these lobes being formed by the umbilical notch and the attachment of the falciform ligament.

The posterior surface is also roughly triangular in shape and very uneven, being rounded and broad behind the right lobe but narrow on the left. It is composed of a portion of the left lobe, the Spigelian lobe, and caudate lobe, and a small strip of the right lobe.

The superior surface is convex and includes the upper surface of the right and left lobes.

The inferior surface is uneven and concave and embraces the lower surface of the left and right lobes and that portion lying between the umbilical fissure and the gall bladder, known as the quadrate lobe.

The right surface is convex from before backward and often convex from above downward. It is made up entirely of the right lobe.

The fissures may be divided thus:—The transverse or portal, which is the hilus through which the great vessels and nerves enter and the hepatic duct passes out, and which lies between the quadrate lobe in front and the Spigelian and caudate lobes behind. The longitudinal fissure lies between the right and left lobes. This is subdivided anteriorly into the umbilical fissure lying between the quadrate and left lobes of the liver, and posteriorly into the fissure of the *ductus venosus*, which lies between the lobe of Spigelius and the left lobe.

The fissure of the vena cava lies between the Spigelian lobe and the right lobe. In this fissure lies the vena cava,

and it is often converted into a canal by liver substance bridging over around the vena cava.

With one exception the ligaments are peritoneal folds. The coronary ligament connects the posterior surface of the liver to the diaphragm. The suspensory or falciform ligament is a part of the old anterior mesentery of the stomach and duodenum. It is a thin membrane which passes between the anterior abdominal wall and diaphragm and the upper surface of the liver. It contains, between its two layers, the obliterated umbilical vein, the round ligament. Others are the gastro-hepatic, the hepato-duodenal, hepato-colic, hepato-renal, cystico-duodenal, and right and left lateral ligaments; the names indicating in each case their situation.

The blood supply of the liver is derived from two vessels, the hepatic artery and the portal vein. These blood-vessels together with the bile duct ascend to the liver in the gastro-hepatic omentum and enter through the transverse fissure; after this all three divide into right and left branches for the respective main lobes of the organ. The liver is peculiar in its blood supply in that the main source is that of the portal vein which receives blood from the digestive tract, pancreas, and spleen.

The hepatic artery and portal vein, in company with the bile duct, penetrate throughout the liver and are surrounded for some distance by an areolar investment, the so-called capsule of Glisson.

The hepatic veins which convey the blood away from the liver pursue through the substance an entirely different course from the other vessels and pass out at its posterior surface, where they empty by two or three main branches and several smaller ones into the inferior vena cava.

The lymph vessels of the liver are divided into a superficial and a deep system. These will be described in detail subsequently.

The pneumogastric nerves, especially the left, and branches from the cœliac plexus, constitute the nerve supply of the organ. These enter the liver along with the great vessels and may be traced throughout the portal canals.

The excretory system of the organ is made up of the hepatic ducts which extend throughout the portal canals and which gradually converge toward the hilus to form one duct, the hepatic duct. The hepatic duct descends in the gastro-hepatic omentum for a variable distance, usually from 3 to 4 cm., and there meets with the cystic duct descending from the gall bladder, and the two ducts uniting at an acute angle form the common bile duct.

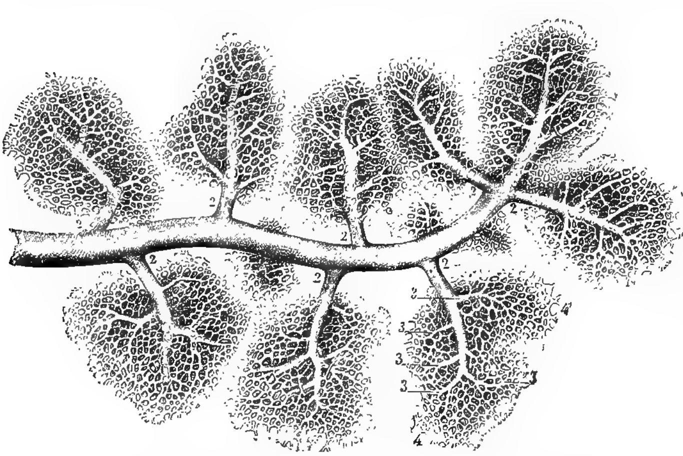


FIG. 3212.—Showing the Origin of the Hepatic Veins. (Sappey.)

The gall bladder is a pear-shaped sac measuring from 7 to 8 cm. long and from 2.5 to 3 cm. broad at the fundus. It is fastened to the liver by connective tissue, blood-vessels, and in part by peritoneum. The fundus extends beyond the anterior margin of the liver in the region of the incisura vesicalis, while the neck of the bladder usually extends in the posterior and upper part of the vesical fossa close to the transverse fissure. It is continued in a spiral curve into the cystic duct. The curved groove on the surface corresponds to a more or less pronounced spiral fold which traverses the interior of the duct and is known as the Heisterian valve.

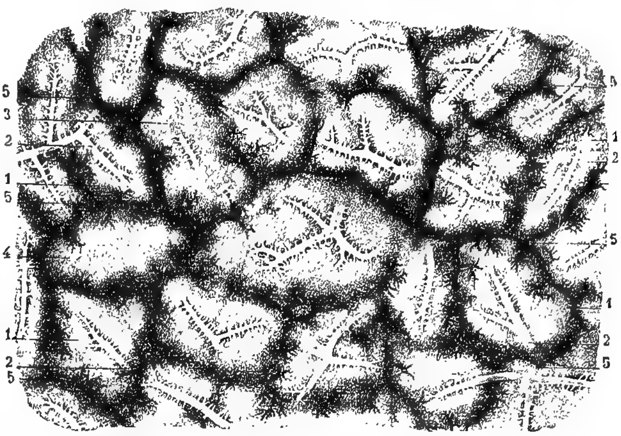


FIG. 3213.—The Vascular Arrangement of the Liver Lobule. 5, Interlobular blood-vessels; 2, intralobular or central veins. (Sappey.)

The common bile duct results from the union of the hepatic and cystic ducts, and it is through this channel that bile is conducted to the duodenum. The duct is from 4.5 to 5 cm. long and about 0.25 cm. in diameter and lies in the gastro-hepatic omentum to the right of the hepatic artery.

The liver surface is covered in part by two coats: the peritoneum and a connective-tissue investment. The former does not extend over the entire surface; the latter, however, is present everywhere and connects the serous coat to the glandular substance. Its inner surface is in direct contact with the liver cells and extends in between the lobules to form the interlobular connective tissue. At the transverse fissure, this areolar tissue is present in greater amount and is found to penetrate into and throughout the liver substance. It surrounds the branches of the portal vein, hepatic artery, and bile ducts, and, forming a coarse framework lying between the lobules, ultimately becomes continuous with the connective-tissue investment covering the surface of the organ. The connective-tissue stroma which penetrates throughout the liver and envelops the portal veins, hepatic arteries, and bile ducts is known as the capsule of Glisson.

A slight coat of fibrous tissue is also discovered about the branches of the hepatic vein. This is never very marked and is continuous from the surface of the organ where the larger hepatic veins empty into the vena cava.

The liver may be described as a tubular gland which has a more or less net-like arrangement. If studied with the naked eye it is found to be made up of small portions which are more or less spherical in general contour. This is especially well marked in some animals, such as the pig. These small portions are known as the liver lobules, and they are separated from one another by connective tis-

sue, the capsule of Glisson, in which the larger blood-vessels, bile ducts, nerves, and larger lymphatics lie. Slight magnification shows the lobule to have a radial arrangement, which is produced by the irregular-shaped columns of liver cells and intervening intralobular blood capillaries.

In the centre of each lobule a blood-vessel of considerable size is discovered, which is known as the central vein or intralobular vein, and which is found to empty into the sublobular vein at the base of each lobule. The latter in turn is found to empty into branches of the hepatic veins which eventually empty into the inferior vena cava.

Radiating from the centre of the lobule to the periphery are discovered numerous branching and anastomosing columns of liver cells which form the parenchyma of the organ, and lying between these are to be seen in part fine blood channels (the intralobular blood capillaries) and in part the intralobular connective tissue.


FIG. 3214.—The Bile Capillaries and Interlobular Bile Duct from an Adult Pig. Golgi method. (Hendrickson.)

The blood capillaries, therefore, constitute a network throughout the lobule and are formed from branches of the portal vein and hepatic artery which lie in the capsule of Glisson at the periphery of the lobule.

In man the liver lobule is not always a discrete unit as in some of the lower animals, but very often is found to contain two or more central veins, while the distribution of the portal canals is not always regular.

The liver cells are of a polyhedral or rhomboid form having a mean diameter of from 0.017 mm. to 0.22 mm. They possess no cell membrane. They are colorless, but contain a variable number of yellow or brownish pigment granules in their protoplasm, and the cytoplasm has a finely granular appearance. It often happens that a cell may have two nuclei, while frequently two nucleoli may be discovered in a single nucleus. The nuclei are round and clear and of the vesicular type.

The hepatic cells are often found to contain, under normal conditions, but especially after the ingestion of fatty food, a considerable number of fat droplets; these are most numerous in those cells which are nearest the periphery of the lobule. Also under certain conditions irregular amorphous masses or globules of glycogen may be present in the cells. When present in considerable amount the protoplasm of the cells is converted into an open network. By means of various methods—the silver chromate impregnation employed by Golgi, the injection of sulphoindigotate of soda, into the blood-vessels of living animals, and the injection of colored aqueous masses into the hepatic ducts—the demonstration of the finer biliary passages within the lobule has been rendered comparatively easy. These methods show a close network of very fine channels between and around the individual cells, much finer and closer than the blood capillary network from the branches of which they run apart. These fine passages are the commencement of the biliary ducts into which at the circumference of the lobule they open. It is uncertain whether they have a definite wall or whether they are merely channels grooved out between the hepatic cells. In all animals the bile canaliculi are separated by at least a portion of a liver cell from the nearest blood capillaries. The natural injection method as well as im-

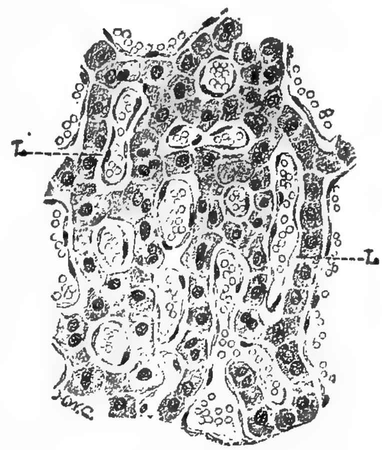


FIG. 3215.—Showing Finer Structure of Hepatic Cells and Intralobular Lymphatic Channels, *L*. (Hendrickson.)

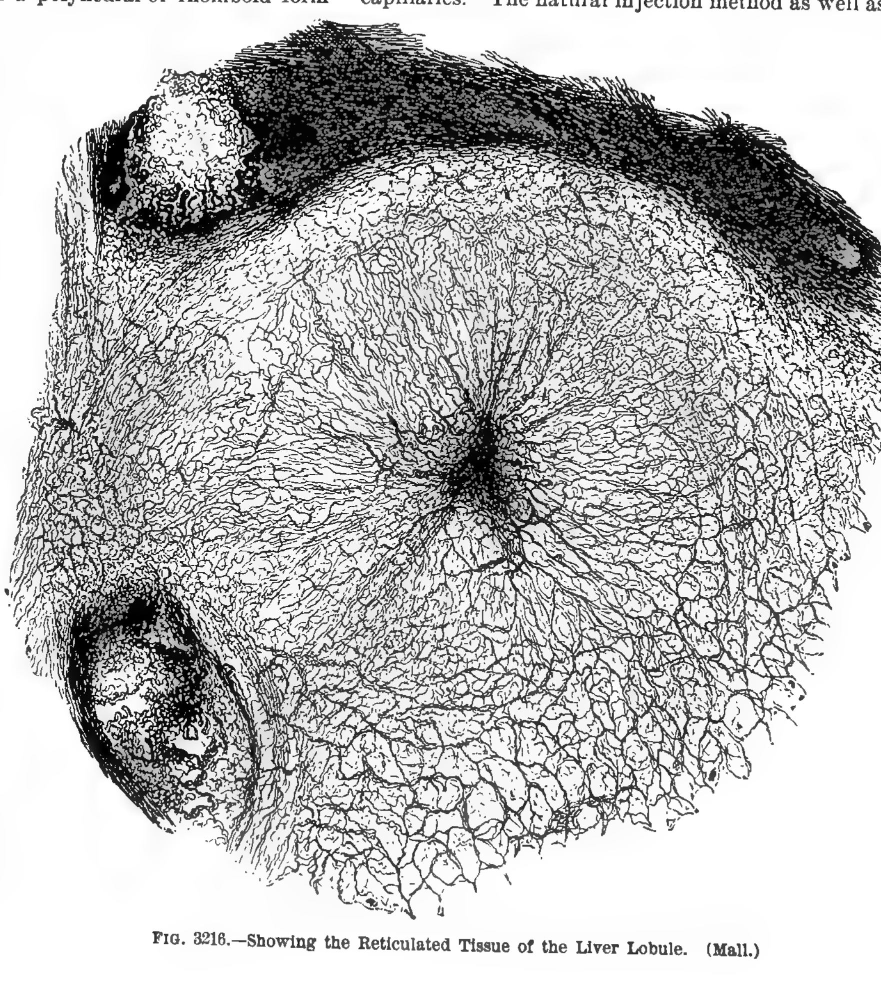


FIG. 3216.—Showing the Reticulated Tissue of the Liver Lobule. (Mall.)

pregnations with silver chromate would seem to show an even closer relation between these intercellular bile capillaries and the hepatic cells; for, with little effort, we can readily demonstrate very small vacuoles in the liver cells which are seen to communicate by a fine hair-like canal with the intercellular bile capillary. Several of these vacuoles can be demonstrated in the same plane of a liver cell. It has been thought by some observers, however, that these terminal structures within the liver cells are formed only at the moment of secretion and are not, therefore, permanent structures.

At the periphery of the lobule the bile capillaries open into the larger interlobular bile ducts which lie within

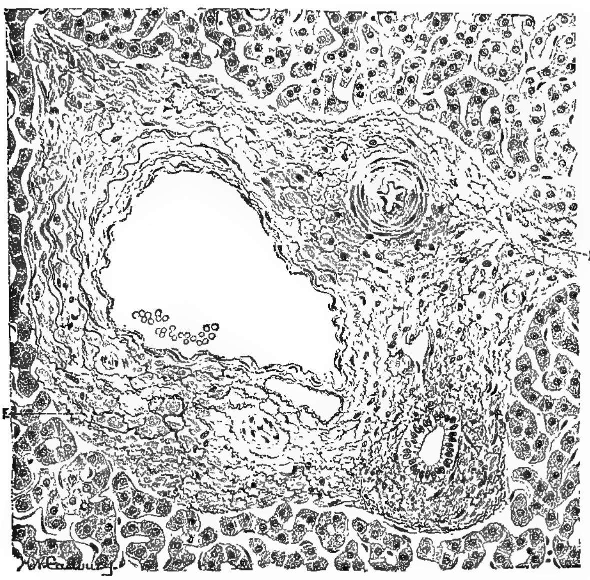


FIG. 3217.—The Elastic Tissue of a Portal Space, *E*. (Hendrickson.)

the portal canal. These small interlobular canals have walls composed of connective tissue and a basement membrane which lies just outside the layer of short columnar epithelial cells which lines the fine lumen. Lying within the connective-tissue coat are found smooth muscle cells which are distributed in a longitudinal, a transverse, and a diagonal direction with reference to the long axis of the bile duct.

As these ducts approach the lobules, the lining epithelial cells become gradually flatter and flatter and at the point where they reach the liver cells at the periphery all lining cells apparently disappear. The basement membrane gradually disappears with the epithelial cells. Throughout the portal canals down to the large hepatic ducts the interlobular ducts preserve the same structure as described above. The epithelial cells, however, lining the ducts gradually become higher as the larger ducts are approached, while the connective tissue and smooth muscle forming the walls also become much more prominent.

The lymphatics of the liver are divided into a superficial and a deep set. The former are found as a subperitoneal plexus over the entire surface of the liver. Those over the anterior and superior surfaces gradually unite and communicate through the hepatic ligaments with the thoracic lymphatics. The plexus on the under surface of the liver, on the other hand, drains into the lymphatics of Glisson's capsule.

The deep lymphatics are found distributed throughout the liver in the portal canals, about the hepatic veins, and within the lobule. Surrounding each column of liver cells within the lobule is found an incomplete small lymphatic space which in section is demonstrated as a narrow channel separating the blood capillary on both sides from the liver cells. These small channels are the ultimate lymphatic radicles, and it is from this intralobular lymphatic plexus that the larger lymph vessels of the portal canals convey the lymph to the transverse fissure through the capsule of Glisson. The lymph radicles about the hepatic veins also receive lymph from this intralobular plexus.

The connective-tissue stroma of the liver is found in largest amount between the lobules, in the capsule of Glisson. This, as has been described, is found to penetrate throughout the liver and ultimately becomes continuous with the subperitoneal connective-tissue coat which covers the entire surface of the organ. Not all the connective tissue, however, is limited to the periphery of the lobules, for close observation shows not only some fibrous tissue about the hepatic veins but also a fine network throughout the lobule.

By special stains and a variety of digestion methods it has been possible more carefully to analyze the different forms of tissue which make up this stroma.

It has been demonstrated that throughout Glisson's capsule white fibrous tissue is present in large amount, and this is readily recognized not only by the general form and coarseness of the fibres, but has been proved by definite chemical tests. In addition to this, however, the so-called reticulated tissue or reticulum is also present in considerable quantity, and this is of special interest inasmuch as it has been found that the intralobular connective tissue is entirely of this variety. Elastic tissue is present in small amount, except in the coat of the large blood-vessels where it is present in considerable quantity.

The entire excretory apparatus of the liver, including the hepatic duct, cystic duct, gall bladder, and common bile duct, are found microscopically to possess the same architecture.

They are lined throughout by a mucous membrane with columnar epithelial cells. Next to this the wall consists of a connective-tissue and muscular coat, and finally, in the case of the gall bladder, beyond this there is a peritoneal investment.

Because of the special clinical interest in the musculature of the biliary passages, and especially that portion which is known as the duodenal papilla, a somewhat fuller treatment than is usual will be given.

By special maceration methods the musculature of the bile passages has been re-examined by the author. Other confirmatory methods, such as sectioning, show a similarity of results in all cases.

In the gall bladder, as has been previously mentioned, the arrangement of the smooth muscle fibres is plexiform. Those, however, which run transversely * to the long axis of the bladder are most numerous. The muscle bundles are not arranged in definite and regular coats; the transverse, longitudinal, and diagonal bundles mingle without conformity to any rule. The muscle bundles are more or less separated from one another by a certain amount

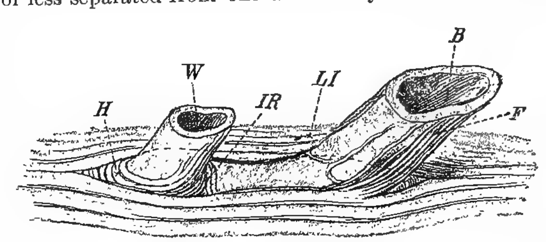


FIG. 3218.—Macerated Duodenal Portion of the Common Bile Duct of Man. Showing the entrance of common bile duct and pancreatic duct into the intestine. × 5. (Hendrickson.)

of connective tissue, but since the individual muscle bundles overlap, there are few if any places in this coat where muscle is entirely absent.

In the cystic duct the smooth muscle is also found to

* The terms transverse, longitudinal, and diagonal are used with reference to the long axis of the gall bladder and its ducts.

have a plexiform arrangement, so that the smooth muscle bundles are seen to run in three directions, viz., transverse, longitudinal, and diagonal. The transverse bundles however, are about equal in number.

In that portion of the cystic duct which is nearest the gall bladder the amount of muscle is considerable, but this gradually diminishes in amount as the common bile duct is approached. At the junction of the cystic, hepatic, and common bile ducts the quantity of muscle present is very small.

Muscle fibres are also present in those folds of the cystic duct which are known as the valves of Heister, and these are found to have the following distribution:

The transverse muscle bundles of the cystic duct are not limited to the wall proper, but at the level of the valves of Heister also run around in the valve in a circular direction. Most of the longitudinal bundles of the cystic duct continue down the duct without entering the valve, but still there are some of these bundles which (having reached the level of the valve) bend around at almost a right angle and run out into the fold. We have no evidence that the diagonal fibres take any part in the musculature of the valves of Heister. Those valves which are nearest the common bile duct are quite small and either contain very little muscle or none at all.

The hepatic duct contains a small amount of smooth muscle, and that which is present is found to follow three directions, longitudinal, transverse, and diagonal.

The longitudinal fibres are most numerous.

Although the amount of muscle in the common bile duct is small, it is found to be distributed in a manner similar to that found in the hepatic duct.

Preliminary to the description of the duodenal portion of the common bile duct, it will be well to state that many individual variations in structure occur, but that these variations do not alter the general anatomical bearing of the region. Fig. 3218 shows the entrance of the common bile duct, *B*, and the duct of Wirsung, *W*, into the intestinal wall. We see a simple separation of the fibres of the outer longitudinal muscular coat of the intestine, *LI*. The common bile duct and the duct of Wirsung pass through this separation. At *F* we find muscle fibres arising from the outer longitudinal muscular coat. These fibres run up on the common bile duct and, becoming gradually less and less marked, finally disappear.

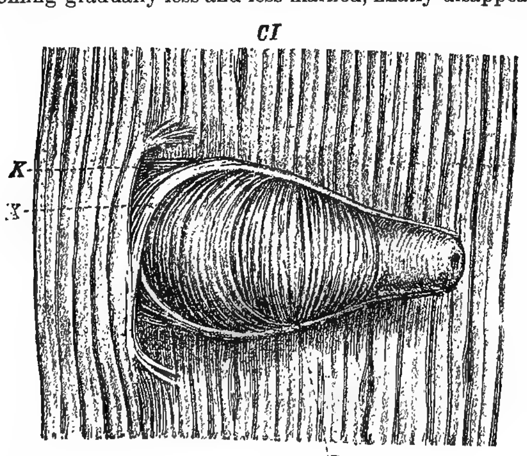


FIG. 3219.—Macerated Duodenal Portion of the Common Bile Duct of Man. The mucous membrane, muscularis mucosæ, and submucosa of the intestine have been removed. × 5. (Hendrickson.)

This arrangement is bilateral. The fibres marked *IR* represent some bundles of muscle which (shown in Fig. 3220, *IR*) form an independent ring of muscle around the common bile duct, between it and the duct of Wirsung.

At *H* are seen muscle fibres which run almost entirely around the duct of Wirsung; but as these fibres approach that side of the pancreatic duct which is nearest the common bile duct, they turn abruptly and run up on the duct of Wirsung in a longitudinal direction. They gradually diminish in volume as they ascend the duct. This structure is bilateral. See also Fig. 3220, *H*.

Fig. 3219 represents the structures seen upon removal of the mucous membrane from the intestinal wall in the region of the duodenal papilla. The inner circular muscular coat of the intestine is represented by *CI*. The first point to demand attention is the penetration of the inner circular muscular coat by the common bile duct. At the spot of penetration there is a simple separation of the muscle bundles of the inner circular muscle coat.

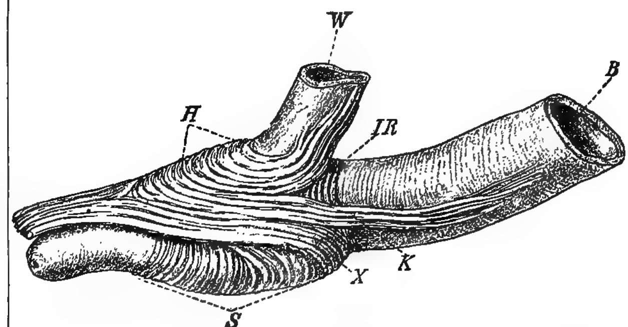


FIG. 3220.—Macerated Duodenal Portion of the Common Bile Duct of Man. All of the intestinal coats have been removed. × 5. (Hendrickson.)

At *S* are bundles of muscle running around the common bile duct (see also Fig. 3220, *S*). These are independent rings of muscle which embrace the duct. Now, if we look farther back on the common bile duct, near the point at which it penetrates the inner circular muscular coat, we observe muscle bundles, *X*, which do not run entirely around the duct. These muscle bundles are very intimately mixed with the independent muscle rings which completely embrace the duct. The former, however, upon reaching the level of the inner circular muscle coat, turn abruptly forward and under the bile duct, and after running for some distance toward the duodenal papilla finally end in the connective tissue of the submucosa of the intestine (see also Fig. 3220, *X*). This arrangement is bilateral. The drawing shows that this arrangement of muscle about the common bile duct begins at a point before the duct penetrates the inner circular muscular coat. In this particular specimen, a muscle bundle of the inner circular muscular coat curves around and becomes continuous with the fibres marked *X*.

Finally in Fig. 3220, a bundle of muscle fibres, *K*, can be seen on each side of the common bile-duct running parallel with it. These bundles arise on the surface of the common bile duct (Fig. 3219, *K*) and are covered by the fibres, *F*, of Fig. 3218. In this case they run forward from under the inner circular muscular coat (Fig. 3219, *K*) and bend around beneath the common bile duct, becoming continuous with each other, thus forming a loop around the duct of Wirsung (Fig. 3220, *K*).

William F. Hendrickson.

LIVER, DISEASES OF: ABSCESS.—DEFINITION.—An affection characterized by the production of one or more areas of necrosis and puriform softening in the liver, due to the action of micro-organisms, and associated with more or less marked degeneration of the intervening parenchyma.

DISTRIBUTION.—Suppurative hepatitis (hepatitis apostematosa), as a primary disease, occurs in the temperate zones with the greatest rarity, but is more frequent in tropical and subtropical climes. As we meet it in the temperate regions, apart from cases due to trauma and wound infection, it is practically always metastatic or due to extension of inflammation from neighboring organs.

ETIOLOGY AND PATHOGENESIS.—It may be taken as

practically certain that all forms of suppurative hepatitis are due to the activity of micro-organisms, either bacterial or protozoan. The forms which have been found, and consequently regarded as etiological factors, include the streptococcus, the staphylococcus albus and aureus, the bacillus coli, the diplococcus pneumoniæ, the bacillus pyocyaneus, the ray fungus, and the amœba coli.

Bacterial agents may reach the liver in several ways, namely, by the hepatic artery, the portal vein, and the bile ducts; or, again, by direct extension from contiguous parts. Rarely, infection occurs by retrograde metastasis from the vena cava or hepatic vein.

Some idea of the frequency of the various forms may be gathered from the following figures: In 1,474 autopsies of which I have notes, occurring at the Royal Victoria and the Montreal General Hospitals, 22 cases of liver-abscess were found. Of these, 3 cases were due to dysentery, 13 were from portal infection, 3 were biliary, 1 was arterial, 1 occurred by extension, and 1 case was apparently primary.

Apart from metastatic cases some occur which are attributable to trauma. Here, in a previously healthy organ, a severe blow or crush results in a necrosis of an area of liver substance, and this subsequently undergoes liquefaction. This event is best explained on the hypothesis that the liver normally contains bacteria. I have satisfied myself by culture and other experiments that the healthy organs contain bacteria, and these results have been amply corroborated by the work of Dr. W. W. Ford[1] at McGill University. In suitable preparations also bacteria can be traced from the surface of the intestine through the mesenteric lymphatics and glands to the liver, so that it is evident that there is what may be called a "vital absorption" of micro-organisms, apparently through the agency of phagocytes, and partly by the tissue fluids, from the alimentary tract to the liver. Normally, the liver has sufficient power to resist the action of these germs, which indeed may be of low virulence from the start or may become attenuated in their passage to the organ, so that disease usually does not result. Should, however, from any cause, the resisting power of the liver be diminished, as, for instance, by trauma or toxic agents, infection and degeneration may result. Except upon this theory it is almost impossible to explain certain forms of so-called "idiopathic" abscess of the liver which occur apparently spontaneously, quite apart from dysentery or other ulcerative lesions of the intestinal tract. Birch-Hirschfeld[2] indeed recognized the probability of "idiopathic" liver abscess being cryptogenic, a term which may at last have some more positive meaning in the light of the above researches.

In discussing the subject of liver-abscess it is perhaps most convenient to treat of the disease as falling into two main groups: (1) *Primary suppurative hepatitis*, where the pathological lesion is primarily induced in the liver; and (2) *secondary suppurative hepatitis*, in which the liver is affected by infective agents derived from some diseased tissue external to it.

The first class may again be divided into, (*a*) *Intrinsic*, where the infective agents are originally present in the liver. It is to this form, inasmuch as it occurs apparently spontaneously without any association with dysentery or any other obvious cause, that the unsatisfactory term "idiopathic" has been applied. Most cases of traumatic origin may also be placed in this class. (*b*) *Extrinsic*, where the agents are introduced from without. An example of the latter is seen in "wound infection" of the liver.

By far the most common event is for the inflammatory process to be secondary to disease of some other organ.

Inasmuch as the tropical form of the disease is of the greatest practical importance and presents many features peculiar to itself, it has been thought advisable to treat of it under a separate heading (see p. 532) and to discuss first those forms of abscess which are liable to be met with in temperate regions.

Abscess of the Liver from Arterial Infection.—In this form, which is really but one manifestation of general septicopyæmia, the infective agents reach the liver through the hepatic artery. In the vast majority of cases, if not in all, the micro-organisms are not sufficiently numerous to cause blocking of the vessels immediately, but become entangled in the endothelium of the finer capillaries where they proliferate, leading to thrombocapillaritis and complete obstruction. True embolism is by no means common; when this occurs it is generally due to ulcerative endocarditis.

The etiology of this form is that of septicopyæmia in general. The primary foci whence the infective agents gain entrance to the general circulation are very various. The disease may complicate all forms of wound infection—osteitis, osteomyelitis, gangrene of the lung, putrid bronchitis, bronchiectasis, suppurative lesions about the bladder, prostate, and urethra, from the uterus after delivery, and ulcerative endocarditis and aortitis. It has also been known to follow such simple affections as carbuncle and whitlow, and is occasionally met with as a complication of the acute infective fevers. The organisms usually at work are the streptococcus pyogenes and the staphylococcus albus and aureus. Some writers note that injuries to the head occasionally result in abscess of the liver, but according to K. Bärensprung, who has made an investigation into this point, liver abscess is not more specially related to injuries of the head than to those of the peripheral parts generally. Most of these cases are examples of septicopyæmia, but some are possibly due to retrograde embolism.

Suppurative Hepatitis of Portal Origin.—This is by far the most frequent form. In this case we have practically a septicopyæmia confined to the liver, for it is upon this organ that the brunt of the disease is concentrated. Infective agents may come from any part of the portal tract. They do not necessarily cause disease of the larger venous trunks, but may reach the finer capillaries, where they proliferate and lead to inflammation and obstruction of the vessels. Often the lesion is an acute thrombophlebitis of the portal vein, or a purulent infiltration of the vessel wall and the adjacent parts (supurative portal pylephlebitis). An example of this is seen in the case of infection of the umbilical vessels in new-born children. It is fairly common in appendicitis and perityphlitis, which form the most important cause. Here there is likely to be thrombophlebitis of the superior mesenteric vein extending directly from the appendicular region into the portal vein. In 517 cases of appendicitis collected by Dr. George E. Armstrong,[3] of Montreal, from the clinics of the Royal Victoria, Montreal General, and Western hospitals, in 67 that died thrombophlebitis of the mesenteric vessels and abscess of the liver occurred five times. Again, combining the statistics of Einhorn, Langheld, and R. H. Fitz, we find that in 479 post-mortems upon appendicitis cases, pylephlebitis and abscess of the liver were found in 23 cases, or 4.8 per cent. Septic emboli occasionally arise from the small intestine, stomach, spleen, and pancreas, and also occur in dysentery, pelvic abscess, and rectal disease. Exceptionally, in cases of cholecystitis and pericholecystitis, extension of the process to the portal vein may take place, and thus an embolic infection of the liver result.

In the septic embolic and metastatic forms one sees a number of abscesses of varying size. These are usually irregular, pointing to their development from the confluence of isolated foci. Occasionally the union is not complete, so that the abscess presents a more or less lobular arrangement. In the periphery of the larger abscesses, and separated by relatively healthy tissue, minuter areas of suppuration can often be seen. The suppurative process tends to spread along the portal sheaths, but the hepatic veins do not always escape, for thrombi may be found in them extending even into the larger trunks. The cavities are filled with viscid, yellowish-green pus, of foul odor, often mixed with blood, in which sequestra of liver substance may often be found. Round about the abscesses is a narrow zone of yellowish-white color, or, in gangrenous inflammation, of a dirty green appearance.

Microscopically, a study of the most recent lesions

shows that the smaller branches of the portal vein and the capillaries are blocked with micro-organisms; the liver cells in the neighborhood are swollen, hyaline-looking, and compressed; the nuclei stain badly, and there is a condition resembling coagulation necrosis. At the periphery of the necrosed area is a zone formed of inflammatory leucocytes which gradually insinuate themselves between the columns of liver cells. Necrosis and softening go hand-in-hand until a local abscess is the result. The liver substance between the abscesses usually shows parenchymatous degeneration. When the abscesses are near the surface, the Glisson's capsule is usually infiltrated, its serous covering granular and inflamed, with loss of the endothelial cells and often a deposit of fibrino-purulent exudate.

Suppurative Hepatitis of Biliary Origin.—Here infection takes place from the bile passages. The most common cause is cholelithiasis with consecutive cholecystitis and cholangitis. In this form the affection may arise in three ways: (1) Direct extension of an ulcerative process due to gall-stones, to the liver; (2) suppurative cholangitis and pericholangitis; (3) through the blood-vessels of the mucous membrane and the bile-passages extending to the portal vein.

The bacteria usually found in such cases are the streptococcus, the staphylococcus, the bacillus coli, and the proteus vulgaris.

Another cause is obstruction of the duct by carcinoma or by the presence of echinococcus-cysts. Sometimes the bile-passages are secondarily affected from the intestines, as in dysentery or typhoid. Lannois [4] has recorded a case of liver-abscess developing in typhoid; such an event seems to be excessively rare. Mayo Robson,[5] again, has pointed out the association of suppurative cholangitis with influenza. Rarely, intestinal worms (ascarides) may invade the common bile duct and, dying there, give rise to marked disturbance. Leick has tabulated nineteen instances of this.

The description already given of abscess arising from the portal vessels holds fairly well for this variety; the main difference is that the abscess contents are often stained with bile and contain gritty matter or concretions.

Suppurative Hepatitis per Extensionem.—A fairly common form of hepatic suppuration is that due to the direct extension of an inflammatory process from some organ in the neighborhood. In this case the suppuration is usually superficial, affecting the capsule and the tissue immediately beneath it. Among the lesions which may extend to the liver may be mentioned diaphragmatic and subdiaphragmatic abscess, suppurative cholecystitis and choledochitis, perforating ulcers of the duodenum and stomach, perinephritic abscess, and abscess of the head of the pancreas.

Symptoms and Physical Signs.—(*a*) In suppurative hepatitis of arterial origin the symptoms are those of general septicopyæmia with the addition of certain ones referable to the liver itself. Almost at any period after the infliction of a wound or the formation of a suppurative focus in the body the affection may appear. Rigors set in with the characteristic "church-steeple" temperature, with profuse sweating. The liver is uniformly enlarged, and there is pain in the right hypochondrium which may be spontaneous but more often is merely a dull sense of tension. The heart is weak and rapid, the respirations are shallow; the skin is often icteric or subicteric, and emaciation takes place rapidly. Diarrhœa almost invariably occurs, and the patient sinks into the so-called "typhoid state," with perspiration, drowsiness, delirium, subsultus, and finally coma and death.

(*b*) In suppurative portal pylephlebitis the symptoms are rarely so striking as in the first form. There are usually irregular chills, fever, and sweating, followed by "typhoidal" symptoms. In some cases rigors and sweating do not occur, and in still others the disease develops insidiously without fever, its existence being evidenced only by pain over the liver, and enlargement of the organ, with subsequent subsidence into the "typhoid" state. Sometimes, as in a case of appendicitis with liver-abscess that occurred under my own observation, there are singularly few symptoms pointing either to the primary affection or to involvement of the liver.

(*c*) Suppurative cholangitis. When gall-stones are the cause there is severe pain occurring in paroxysms, each attack being associated with chills, fever, and jaundice; pain may, however, be entirely absent. Fever and profuse perspiration, followed by emaciation, are marked features. The so-called "fièvre hépatique intermittente" of the French writers is in the majority of cases due to cholelithiasis and abscess of the liver. There is usually a gradually increasing enlargement of the whole liver, which is tender on pressure; occasionally the gall-bladder is enlarged and can be felt, but it is more often contracted. These symptoms are usually followed by general systemic infection. Similar symptoms may be found in non-suppurative cholangitis, but when suppuration is present fever is constant and the deterioration is progressive.

Tropical Abscess.—This form is characterized by the development of one or more foci of colliquative necrosis in the liver, either with or without dysentery. As the name suggests, the disease is most common in tropical and subtropical regions. Unlike the forms incident to temperate climes, where the tendency is for multiple areas of suppuration to form, here large single or, at all events, relatively few abscesses are produced. The abscesses are often so extensive that they are enclosed by merely a thin shell of liver substance.

The etiological factors are as yet but imperfectly understood. It is probable that the liver parenchyma undergoes some form of gradual death previously whereby its resisting power is impaired, and thus infection is brought about more readily. In this it differs from the pyæmic forms in which the parenchyma is originally intact.

The exact relationship of tropical abscess to dysentery is still *sub judice*. There can be no question that the large solitary abscess occurs occasionally apart from any obvious intestinal lesion, but most authorities are agreed that the largest number of cases are associated with dysentery. As yet statistics are lacking to enable us to supply the relative frequency of the various etiological factors. Kartulis [6] states that in 500 cases of liver abscess which came under his notice, 55 to 60 per cent. gave a history of dysentery. Conversely, Lafleur [7] states that 20 to 25 per cent. of cases of dysentery in the tropics are complicated by liver-abscess, and these figures are corroborated by those of Manson,[8] who in 3,680 autopsies on dysenteric patients found liver-abscess in 21 per cent. Hirsch,[9] in 2,377 autopsies in tropical dysentery, found liver-abscess in 19.2 per cent. There must, however, be something peculiar in the form of the dysentery, for, as is well known, in the catarrhal dysenteries and the ulcerative forms found in the temperate zones, liver-abscess is excessively rare.

Some few cases appear to be due to some other affection apart from dysentery. A certain proportion of these seem to be brought about by dietetic errors; free living, excessive use of animal food, and particularly excess in alcohol, are said to be potent causes. Sachs [10] has advanced the view that in the temperate zones alcohol, as it affects the liver, is apt to lead to chronic fibrosis, but in the tropics to a suppurative lesion.

Race exercises an important influence, for whites are much more liable than the native races to abscess of the liver. The proportion is estimated by some to be 35 to 1. The disease affects adults rather than children and males rather than females. Rouis [11] and De Castro [12] lay stress upon the extreme rarity of the disease in females, and this is corroborated by the Berlin statistics collected by K. Bärensprung,[13] according to which only about 1.48 per cent. of the cases occurred in women. The disease is, furthermore, more common in the cold, changeable season which follows after the summer's heat.

With regard to the ultimate nature of the process, our information still lacks precision. It would seem probable—and this view is certainly in harmony with the

most recent studies as to the nature of infection—that the non-dysenteric forms are due to some preliminary deterioration of the resisting power of the liver parenchyma. Excess in diet, extreme heat, lack of exercise, sudden changes in temperature, may all play a part here. Congestion of the liver is no doubt readily induced in this way, and this leads to impairment of the liver function, stagnation of bile, and a tendency to portal congestion. Catarrh of the intestines and even trifling ulceration might easily follow, affording a ready mode of entrance for pyogenic micro-organisms. Again, the liver in its turn would suffer from the portal toxæmia thus produced, and a true vicious circle is the result. That under such circumstances an abscess of the liver might result is certainly not to be wondered at. The bacteria found are the pyogenic cocci.

As the studies of Kartulis, Lösch,[14] Kruse and Pasquale,[15] Councilman and Lafleur[16] have shown, a fairly large proportion of the dysenteric cases are due to a protozoan, the amœba coli, or amœba dysenteriæ. What this proportion is is still uncertain. Flexner,[17] the most recent authority, is of the opinion that the great majority of dysenteric cases are of amœbic origin. The failure to find the amœbæ in the abscess in some cases is probably due to the fact that only a superficial examination has been made, for by scraping the walls of the abscess it is usually possible to demonstrate the living protozoan. It is further probable that many of the so-called "idiopathic" abscesses are really dysenteric in origin, for numerous instances are on record in which only after the most minute examination of the intestine was it possible to find traces, in the form of minute scars, of a dysenteric process which had healed, traces which might readily have been overlooked. In many cases bacteria have been found, notably staphylococci and streptococci, either alone or associated with amœbæ.

Some of the earlier authorities were of the opinion that liver-abscess was due to the pyogenic cocci and not to the amœbæ; still others took a modified view, viz., that the amœbæ acted merely as carriers of the germs, and by their growth and movements, which ruptured the capillaries, paved the way for subsequent infection. The most careful observers, such as Councilman and Lafleur, believe, on the contrary that the amœbæ are the direct exciting cause of the lesions when present, and this view has the preponderance of evidence in its favor.

The recent discovery by Shiga of a bacillus resembling that of typhoid in some forms of tropical dysentery, which is now very widely accepted as specific, opens up the question as to this germ being an etiological factor in the production of liver-abscess. Flexner in a large experience did not meet with a single case due to the bacillus of Shiga. A few writers, however, refer to the discovery of a typhoid or typhoid-like bacillus which possibly was this form. Pansini and Babes seem to have obtained the organism, or a similar one, in several cases of abscess of the liver.

Morbid Anatomy.—In seventy-five per cent. of cases the abscess is solitary and in more than half it is situated in the right lobe, commonly on the upper or outer surface. The abscess is at first usually somewhat deeply situated, but may become superficial. In amœbic cases there is a predilection for the dome of the liver or the under surface, near the hepatic flexure of the colon. The contents vary much; in some few cases the fluid is serous, but in most there is a mixture of pus and necrotic material. The pus is generally thick, white, yellowish, or greenish in color, often mixed with blood, and is usually very fetid. In amœbic cases the pus is somewhat characteristic, being in some cases glairy and translucent, in others grayish or brownish-red, and has been compared to anchovy sauce. The quantity varies from a few ounces to many pints. In the early stages the area of necrosis is often scarcely liquefied, being more or less hyperæmic, coagulated, spongy, and infiltrated with a glairy tenacious material; but later, when liquefaction takes place, the abscess becomes diffuse and finally more or less irregular. Its walls are formed of necrotic and shaggy débris of the liver parenchyma. In long-standing cases the abscess becomes walled off by pyogenic membrane or a fibrous capsule. The liver substance surrounding the abscess is generally congested, softened, cloudy, and friable, or shows other signs of degeneration, although in some cases the parenchyma has been found practically normal.

One or two special types may be just mentioned: (1) The "fibrous" abscess of Kelsch and Kiener.[18] In this the abscesses, numbering from three to twelve, are of about the size of a pigeon's egg. They are filled with grayish, grumous, semi-solid material and are enclosed in a stratified fibrous wall. (2) The "abcès aréolaire" of Chauffart,[19] in which the abscesses, extending toward the surface, are in close juxtaposition, and there is more or less free communication between the various cavities, so that a sort of spongy framework filled with rather viscid contents is the result. Adhesive inflammation about the capsule of the liver, the pleura, and the pericardium is not uncommon.

Microscopically, the contents of the abscess, when of the amœbic type, are composed of finely granular detritus, red and white blood cells, hæmatoidin, and degenerating liver cells. The amœbæ are most numerous in the small abscesses. There is widespread necrosis of the liver parenchyma. A somewhat characteristic and interesting point is that leucocytic infiltration is practically absent in the abscess contents and at the periphery of the area, except in cases in which secondary infection has taken place, such as occurs in abscess of the under surface of the liver near the bowel. In the early stages the disintegration always takes place in the interlobular regions. The amœbæ are found chiefly at the periphery of the abscess, in the capillaries, and about the portal sheaths.

Results of Abscess.—Cases of this disease almost invariably end fatally, at least in the multiple forms, but when death does not take place shortly, and if the condition be not relieved by operative interference, the abscess may rupture and give rise to further most serious consequences. The most frequent event is rupture into the right lung or pleura and next into the peritoneum. The latter event is not so grave as might be thought at first, since limiting adhesions, which prevent or delay the occurrence of peritonitis, are not infrequently formed. More rarely, the abscess ruptures into the pericardium; then sudden death may be the result. Again, the abscess may discharge externally or into the transverse colon, the stomach, or the duodenum; very rarely into the bile ducts, the hepatic veins, vena cava, or the pelvis of the right kidney. Pressure upon the bile-passages leads to icterus, and in rare cases obstruction of the portal vein has caused ascites.

In some few cases after a longer or shorter period the process becomes latent or comes to an end. The necrotic material is to a certain extent absorbed, the swelling becomes less marked, connective tissue is developed, and a regular capsule is formed about the abscess. Complete healing can occur, but this seems to be more frequent in the tropical abscess than in the other forms. Small foci of suppuration may be absorbed, with the formation of a scar; larger foci, through the removal of the more liquid contents of the pus, become cheesy and often calcareous. In the latter case the resemblance to a syphilitic lesion or to an old echinococcus-cyst is striking.

Associated Lesions.—Lung: Abscess of the right lung may occur and is always due to the extension of an abscess of the liver situated in the dome of the right lobe. The abscess is never metastatic. The diaphragm is usually adherent to the under surface of the liver and to the base of the lung. Occasionally empyema is present; the diaphragm may be perforated, but not invariably so. The abscess in the lung is usually situated in the basal portion of the organ; the lung tissue in the neighborhood is consolidated; the wall of the abscess is very irregular in shape, or again may be fibrous. Allowing for differences due to the tissue in which it is found, the lesion is strictly comparable, anatomically and histologically, to the process in the liver. Frequently perforation into a

bronchus takes place and the pus thus finds a vent. The material in the abscess generally resembles that found in the liver.

Peritoneum: Local or general acute peritonitis is sometimes found; it is sero-fibrinous in character. In amœbic cases amœbæ may be found free on the surface of the mucous membrane.

Symptoms and Physical Signs of Tropical Abscess.—In many cases the affection remains entirely latent, being discovered only accidentally at autopsy. In still other cases the abscess may remain latent for an indefinite period and then suddenly give rise to acute and fatal consequences, owing to rupture of the wall and involvement of some vital organ. Generally, however, symptoms more or less characteristic are present. These consist of a sense of fulness and weight in the right hypochondrium, inability to lie on the right side, fever, disturbance of digestion, and cough; the patients sometimes feel as if a stick of wood were laid transversely across the upper abdominal region (*sensation de barre*). Pain is extremely variable in amount, but may be an early symptom. When present it is of a dull, boring character or, when the liver capsule is inflamed, lancinating; it is often increased on pressure and when the patient breathes deeply or turns on the right side. A curious feature is that it may be referred to the right shoulder, where indeed it may be more severe than in the hepatic region. Cough is often present and is supposed to be due to reflex irritation. A rise of temperature of from one to three degrees is generally found; in a large number of cases fever is the first symptom. It is usually accompanied by pain in the hepatic region, but occasionally may persist for days or weeks before pain in and enlargement of the liver develop. The fever is not infrequently quotidian in type, or there may be two diurnal exacerbations; these are followed by perspiration.

The irregularity of the attacks of fever is a point of some value in differentiating from malaria. Rigors are not constant. Icterus is one of the rarest symptoms; it is said to arise from pressure of the abscess upon one of the main bile passages. According to Thierfelder,[20] it occurs in about sixteen per cent. of all cases. When hepato-pulmonary abscess exists the condition may be quite obscure. Although the liver is first involved, the physical signs as a rule direct attention first to the lung. The resemblance to pleural effusion is striking. Only when the abscess discharges into a bronchus can we get positive information. Here the expectoration of large amounts of characteristic sputum with a diminution in the size of the liver, signs of consolidation, tubular breathing with consonating râles, increased vocal resonance, and whispering pectoriloquy, are conclusive. Pain in the cardiac region, with signs of suffocation and evidence of pericardial effusion, points to rupture of the abscess into the pericardium. Rupture of the abscess into the stomach is often preceded by pain and irritation in the stomach, and is clearly evidenced by vomiting of necrotic matter; or, again, the material may be discharged by the bowel, an occurrence which also may take place whenever rupture has occurred into any part of the alimentary tract.

Prognosis in Liver-Abscess.—The outlook in all forms of multiple abscess—as, for example, portal pyæmia and suppurative portal pylephlebitis—is practically hopeless. Treves has, however, recorded a case of abscess of the liver complicating appendicitis in which the patient recovered after an exploratory operation. Suppurative pericholangitis, inasmuch as it presents a greater tendency to form isolated large collections of pus, and therefore is amenable to operative interference, is perhaps more hopeful. At best, however, in all forms of hepatic suppuration the outlook is most grave. More is to be expected in those cases of solitary abscess which can be attacked by modern surgical methods. Much depends upon the position of the abscess, its cause, and the possibility of reaching and evacuating it. On account of the gravity of the primary disease, those cases which are associated with dysenteric symptoms are more liable to turn out badly than those in which there is the so-called "idiopathic" abscess. The relatively favorable result in the case of tropical abscess is perhaps to be explained by the fact that the pus is liable to be less virulent and in some cases indeed sterile. It has been estimated that the mortality amounts to from fifty to sixty per cent.

Diagnosis.—The diagnosis of liver-abscess is always attended with considerable difficulty, and in fact the condition may frequently only be suspected. This is especially true of multiple small abscesses or diffuse suppuration. The symptoms which should direct attention to the liver are the onset of a sense of weight and oppression, or of actual pain, in the region of the liver, more or less enlargement of the organ, rigors, irregular temperature, cough, dyspeptic disorders, and diarrhœa. Pain may be spontaneous or elicited only on palpation. Generally the whole liver is tender, but frequently more painful areas, corresponding to the abscesses, can be made out. Lancinating pain during respiration or a friction rub points to perihepatitis. The tendency for the pain to be referred to the right shoulder has already been referred to, but it is not pathognomonic. Enlargement of the liver is not striking in the very diffuse forms, but in the solitary abscess it is somewhat characteristic; the tendency is for the organ to be enlarged upward. Dulness at the base of the right lung in these cases can usually be made out, and there is some limitation of the free movement of the lung. The dulness reaches its highest point at about the mid-axillary line. When the abscesses are in the left lobe, or toward the anterior edge of the enlarged right lobe, they may sometimes be felt as flat nodules which may be so hard as to simulate cancer. Occasionally a fluctuation can be detected. The spleen is not enlarged except in cases of perityphlitis and septicopyæmia.

With the exception of acute yellow atrophy, abscess is about the only grave affection of the liver associated with fever, and here the course of the disease and the alteration in the size of the liver will differentiate. It must not, however, be forgotten that extensive suppuration may exist in the liver without fever.

A condition which will give rise to considerable trouble is croupous pneumonia when associated with enlargement of the liver and icterus. Again, the fever is often remittent or intermittent with chills, and so the affection may be confounded with malaria. A point emphasized by Kelsch and Kiener is the close association of "typhoid" symptoms, viz.: rapid, feeble, and irregular action of the heart, cold sweats, subsultus, drowsiness, emaciation and diarrhœa, ending in coma and death, with the presence of small multiple foci of suppuration in the liver.

The previous history of the case often affords valuable information. The presence of a recent wound or injury, a suppurating focus, or recent parturition will suggest a point of departure for a septicopyæmic process; a sudden onset of fever of a septic type, with chills and violent constitutional disturbance, will indicate a systemic generalization of the process, and these symptoms may be so violent as to mask those referable to the liver. In these cases, pain, either dull or lancinating, a sensation of weight or tension in the right hypochondrium, pain or tenderness on pressure with enlargement of the liver, point strongly to liver-abscess. Jaundice and involvement of the liver alone, however, are not of so much importance since they may be present in septicopyæmia even in the absence of hepatic involvement.

When the symptoms occur during the course of some ulcerative or infective process within the bounds of the portal tract, this will suggest a portal pylephlebitis or periportal abscess formation. In this form, the brunt of the affection falling upon the liver, the symptoms will at first be mainly referable to that organ. And while symptoms of systemic septicopyæmia, namely, metastatic deposits in the lungs, spleen, kidneys, heart, joints, and skin, may develop, they occur invariably later on. In most instances rigors and sweating are less marked than in the septic embolic form, or may indeed be absent.

The main conditions which may be confounded with abscess of the liver are, malaria, cholangitis, right-sided

TABLE FOR DIFFERENTIAL DIAGNOSIS.

Abscess of Liver.	Malaria.	Carcinoma.	Right-sided Empyema.	Abscess of abdominal wall.	Suppurating echinococcus cyst.	Cholelithiasis, cholangitis.
1. History of trauma, suppuration, dysentery, gall-stones, parturition, acute infective fevers.	History usually negative; possibly previous attacks.	Possibly a hereditary taint.	History of recent pleurisy; often insidious in onset.	Often a history of previous typhoid or tuberculosis.	A history of previous painless swelling of the liver, without marked deterioration of health.	History of biliary colic, intermittent jaundice.
2. Pain referred to the right hypochondrium or shoulder.	Pain absent or almost trivial.	Pain variable; usually slight.	Pain may be absent.	Local tenderness.	Pain trifling.......	Pain, paroxysmal, referred to hypochondrium, passing down the leg or through to the back.
3. High fever almost constant, of remittent or intermittent type, with sweats and chills; may be irregular; resists quinine.	Intermittent fever of quotidian, tertian, or quartan type; does not usually resist quinine; fever regularly returns, according to type.	Fever rare; usually continuous; may be intermittent, with rigors.	Fever often irregular; may be absent.	Irregular fever with chills.	....	Moderate fever during the paroxysm, otherwise normal or submormal.
4. Often an icteric or subicteric hue; rarely jaundice.	No jaundice	Jaundice in one-half the cases.	No jaundice	No jaundice	Rarely jaundice ...	Jaundice invariably present, recurrent or persistent.
5. Liver may be enlarged and smooth.	May be moderately enlarged.	Liver enlarged and often nodular.	Liver may be pushed down.	Liver not enlarged.	Liver enlarged	Liver rarely enlarged.
6. May be bulging in right hypochondrium.	Negative	May be bulging..	Negative	Local swelling...	May be bulging ...	Negative.
7. Aspiration often detects pus.	Negative	No pus; sometimes cancer cells.	Negative	Aspiration will detect pus.	Fluid may contain glucose; pus may contain characteristic hooklets.	Negative.
8. Spleen not enlarged except in pylephlebitis or pyæmia.	Spleen enlarged; blood containing plasmodium malariæ.	Negative	Negative	Negative	Negative	Negative.

empyema, abscess of the abdominal wall, carcinoma of the liver and bile passages, and suppurating echinococcus-cysts.

An examination of the blood for the hæmatozoon of malaria will clear up the first question and so also will the therapeutic test; an intermittent fever that resists quinine is not malarial.

The intermittent hepatic fever of cholangitis due to gall-stones presents great similarity to abscess, yet in such cases both fever and chills may occur for years without suppuration. The points of distinction are the paroxysmal attacks of fever, the rigors and sweats, an increase of jaundice during the attacks—all are characteristic of cholangitis, when they occur with intervals of apyrexia, cessation or amelioration of the symptoms, and the preservation of fair nutrition.

A right-sided pleural exudate may be excluded by differences in the curve of the upper level of the dulness at the base of the lung without change of this level by posturing, and by the fact that dislocation of the heart does not occur. These considerations will of course not apply when, as is sometimes the case, the liver-abscess is complicated by acute pleurisy.

In abscess of the abdominal wall the swelling lies more superficially and is not associated with enlargement of the liver. When it is aspirated the needle does not move up and down with the respiratory movement. If, however, the liver be firmly anchored to the abdominal wall by inflammatory adhesions, even in the case of abscess, the movements may be completely prevented.

Suppurating echinococcus-cysts can be differentiated from abscess of the liver only by a comparison of the histories of the two diseases and by an examination of the pus evacuated by aspiration. When the echinococcus is the cause of the suppuration there will be a history of a long-standing painless swelling of the liver, with preservation of fair health, followed by evidences of suppuration; and when the pus is aspirated it will be found to contain the characteristic hooklets.

In cancer of the liver, fever is rare, cachexia is marked, and the disease is essentially chronic. Usually the previous history will throw light on the case.

In all cases of doubt exploratory puncture may be tried without fear of evil consequences. It is well to place the patient under ether, as several punctures may have to be made. The needle may be inserted in the lowest interspace in the anterior axillary line, in the seventh interspace in the mid-axillary line, or behind over the area of dulness. The stools and, if perforation has taken place into the lung, the sputum, should be examined for amœbæ in all cases of solitary abscess.

TREATMENT OF LIVER-ABSCESS IN GENERAL.—In the multiple abscesses found in the liver as a complication of septic infection elsewhere but little can be expected from treatment. As the condition is not often amenable to surgical interference, we have to fall back on the use of the medicinal measures adopted in septicopyæmia generally. Sponging with cool water at a temperature of 65° F. will often control the fever to some extent. Pain must be relieved by mustard, turpentine, or hot fomentations to the hepatic region, and if necessary by opium. Free stimulation and the use of full doses of quinine are advisable. If there are evidences of a large abscess being formed, operative interference may be discussed and the case treated on the same lines as the tropical abscess.

With regard to the tropical form, prevention is better than cure. All Europeans sojourning in the tropics should take special precautions. Sleeping and living rooms should be large and airy, suitable clothing should be worn, and care taken to avoid all sources of chill. Clothing when damp should be quickly changed; moderate exercise is advisable. Diet should be moderate and unstimulating and alcohol should be tabooed; all irregularities of the bowels should be controlled. When signs develop which are suggestive of hepatitis (apart from malaria), whether dysentery be present or not, the patient should be strictly confined to bed on a milk diet. Ipecacuanha should be given in full doses, and intestinal antiseptics, such as benzo-naphthol, should be employed. Occasionally a blue pill is of great benefit. When the acute symptoms have passed off, ammonium chloride should be exhibited in fifteen- to twenty-grain doses three or four times a day and continued for some time. Should an abscess form, it must be treated surgically on the merits of the case. Morphine hypodermically may be given to control pain and relieve cough.

Several methods have been advocated for dealing with large solitary abscesses. These in the main consist of aspiration, siphonage, or open incision. Which method is advisable depends largely upon the position of the ab-

scess and the presence of surrounding adhesions. Aspiration with a stout needle is practically devoid of danger, and should be done under ether so that thorough exploration can be carried out. It is not always possible in this way completely to evacuate the pus, and in any case the cavity is liable to fill again. Nevertheless, some cases of cure after two or three repetitions have been reported. Puncture with a trocar and cannula followed by siphonage is advocated strongly by many Indian surgeons. The method of Manson is first to explore the liver with a hollow needle; when pus is found a small incision is made through the skin and a large trocar and cannula are inserted, care being taken to follow the direction of the preliminary aspiration which revealed the pus. The trocar is pushed in just far enough to reach the abscess, is then removed, and, without allowing any pus to escape, a rubber drain, about nine inches long, is stretched upon a metal rod and carried through the cannula to the bottom of the abscess. The metal rod is withdrawn and the rubber tube stitched to the skin. A long rubber tube is attached to the drain and the contents are allowed to siphon off into a bucket containing antiseptic solution placed at a suitable distance below the patient. An antiseptic dressing, of course, is applied to the wound. Washing out the cavity is not attempted unless the drainage is imperfect and the temperature begins to rise.

Cantlie[21] advocates this method very strongly and reports twenty-four cases cured out of a series of twenty-eight operated upon. When the method of open incision is adopted, a direct opening into the abscess can be made only when the liver is adherent to the anterior abdominal wall. If the wall over the liver is reddened and œdematous, it may be taken for certain that adhesion has taken place. A trocar may be first inserted and a free opening subsequently made. If it be not certain that adhesion has taken place, the operation may be done in two stages. An incision is made through the abdominal walls, the liver is then sutured to the wall, the wound plugged and left till adhesions have formed; subsequently, the trocar may be used till pus is discovered and the track then enlarged with the knife. The sac should be explored with the finger so as to empty any subsidiary pockets.

In more urgent cases and when skilled assistance is at hand an open incision may be made down to the liver; the assistant then holds the liver as nearly as possible in contact with the abdominal wall. Pads are placed so as to prevent infection of the peritoneal cavity, a trocar is thrust in, and when pus is found the opening is enlarged with the knife. After the contents have been evacuated the liver is then stitched to the parietes and the drain inserted. To explore the posterior part of the liver, it may be necessary to insert the trocar through both layers of the pleura and the diaphragm. If an abscess is here found, however, drainage should be established by resecting the rib, stitching the two layers of the pleura together with catgut, and then inserting the trocar and cannula.

Albert George Nicholls.

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LIVER, DISEASES OF: ACUTE YELLOW ATROPHY.—(Synonyms: Ger., *Acute gelbe Atrophie der Leber, acute parenchymatöse Hepatitis;* Fr., *Atrophie Jaune Aiguë du Foie, Ictère Grave; Cholæmia, acholia, icterus gravis,* malignant jaundice.)

Definition.—Acute yellow atrophy of the liver is a general disease, characterized anatomically by a granular and fatty degeneration of the epithelial cells of the glands, the endothelial cells of the blood-vessels, and the muscles of the body, on account of which the evidence of the gross changes of atrophy of the liver, parenchymatous inflammation of the kidneys, catarrh of the gastro-intestinal tract, degeneration of the cardiac muscle, and endothelial degeneration and rupture of the minute blood-vessels, are observed during life. These phenomena are due, in all probability, to a poison in the blood. The poison may be organic (micro-organisms), or inorganic (phosphorus, antimony, arsenic, alcohol); or the poison may be generated in the system (pregnancy, mental emotion, etc.). Quincke believes that in some cases the condition is an outcome of acute parenchymatous hepatitis. The nature of the poison, if it be generated in this manner, is not known. As a fact which bears out the view of an intoxicant or poison, the great similarity to phosphorus poisoning must be emphasized. Hedderich has collected 33 cases of poisoning by phosphorus, in which atrophy of the liver was marked; only one-half of these showed any enlargement preceding the diminution in size of the liver (a point usually considered more or less absolute in phosphorus poisoning). Acute yellow atrophy, phosphorus poisoning, and a group of diseases spoken of as "acute fat degenerations" may be grouped together in point of similarity of lesions and etiology (Quincke). All interest has been previously centred upon the liver, however, on account of its being the largest gland in the body and the one which undergoes the most marked lesions. Now it is believed that all the glands are similarly involved. During life, acute jaundice, nervous symptoms (delirium, coma, and convulsions), alterations in the size of the liver and spleen, changes in the composition of the urine, and general hemorrhages occur. The remarks which follow apply to cases of acute yellow atrophy, in the general acceptance of the term, and therefore exclude that which occurs after phosphorus and other poisoning, and in yellow fever.

Frequency.—Acute yellow atrophy of the liver is a rare disease. Osler states that there are only 250 recorded cases. Thierfelder collected above 140 cases, and Legg 100 for their monographs. One of the writers (Musser) has examined the histories of 50 cases published since 1879, the date of issue of Legg's book. Quite a number of cases have occurred in Philadephlia in recent years. Pepper alone has observed 5 cases; Musser has seen 2, and knows of 3 others. Eight cases only have been recorded in Guy's Hospital in twenty years.

Etiology.—Certain predisposing influences are noted in the etiology of this disease, viz., the age, the sex and habits of the individual, and the season of the year. It occurs most frequently between the ages of fifteen and thirty-five, although cases after sixty have been recorded. Ashby observed a case in a boy, aged four, and Legg refers to several about two years of age, and to one in a new-born child. Merkel has collected 18 cases in children, Schmidt 16 cases under ten years of age. The female sex is most liable to the disease, the proportion being about eight to five. A larger number of the recorded cases have been observed among dissipated persons—prostitutes, drunkards, and those who drink

largely of malt liquors. Syphilis is thought by many to predispose to this affection, and it is said that at the commencement of the secondary stage acute yellow atrophy may become developed, following the jaundice sometimes seen at this period, and may terminate fatally, due to the impress of the syphilitic poison on the constitution. Lebert thought the extremes of heat and cold favored the development of the disease, but the analysis of Legg disproves the predisposing influence of the seasons. Series of cases have been described which appeared to show a marked family tendency to the disease, especially among those of the family who lived together under one roof. They possibly were cases of malignant jaundice, due to some micro-organism—epidemic or endemic in character. Quincke speaks of such cases in epidemics of severe icterus; they have usually been fatal, while the other individuals have merely shown more or less severe symptoms of a toxic jaundice with subsequent recovery. Pregnancy is one of the most marked predisposing causes. The disease usually occurs between the third and the sixth months of gestation. Cloudy swelling and parenchymatous degeneration of all the glands, more marked in the case of the liver and kidneys, is a physiological accompaniment of pregnancy and suckling. Frerichs has insisted upon the importance of this, in connection with the frequency of acute yellow atrophy of the liver in this state. It is known that epidemic jaundice is more fatal in pregnant women than in any other class of people.

The mode of action of the exciting causes of acute yellow atrophy is involved in much obscurity. Nervous influences are considered the most marked exciting cause. Grief, fear, or anxiety may be so great as to excite such morbid changes in the blood as would cause general tissue degeneration. Malaria has also been looked upon as an exciting cause, and the continued fevers and scarlatina have been placed in the same category. Cases have developed after osteomyelitis (Meder), sepsis (Dunkler and Babes), erysipelas, febris recurrens; these may have been nothing more than severe grades of parenchymatous hepatitis. The development of a special poison in the system by nervous influence, or from faulty digestion or assimilation, has been invoked for the causation of this disease. The growth of micro-organisms in the blood and organs has been demonstrated, usually, however, only the B. coli communis, streptococci and staphylococci, and no specificity of action can be claimed; it is more likely that the disease is due to organic or bacterial toxins or even to ptomaïns absorbed from the intestines. Quincke insists that the disease is an intoxication and in no way to be considered an infection; further, that it may be produced by various poisons, giving rise to varying degrees of severity. As one possible cause he gives obstruction of the diverticulum of Vater and consequent overflow of pancreatic secretion into the bile passages and liver. Some of the intermediate products of digestion, the albumoses, have been found to possess highly poisonous qualities, and have been regarded by some as possible agents.

Morbid Anatomy.—On section of the abdomen the liver cannot usually be seen. It is high up against the diaphragm, or placed backward toward the spinal column. It is small, weighing less than one-half or one-third as much as the healthy organ. Sometimes, however, the liver is enlarged, and Liebermeister, with others, believes that enlargement takes place in the early stage of the disease. Of course, acute yellow atrophy may occur in a liver previously cirrhotic or fatty. Its surface is smooth and of a mottled yellow color. The capsule is usually wrinkled, but free from opacity. The organ is thin and limp. On section marked changes in color are seen. The entire cut surface may be uniformly yellow, or yellow alternating with a dark red or purple color. The lemon yellow, ochre, gamboge, or Turkey-rhubarb yellow color is distinctly outlined, or shades into the deep red. In the yellow portion the lobules are indistinct or increased in size. In the red portion the lobules are diminished in size, and with a lens the interlobular connective tissue is observed to be increased. The red portion is more shrunken and firmer than the yellow, which appears swollen and very soft. The red is considered by most pathologists to be a later stage of the yellow. The ducts are patulous; the mucous membrane is bile-stained or covered with mucus. In many cases a catarrh of the finer ducts has been observed. The gall bladder is empty, or contains light-colored bile or only some mucus.

The histological appearances of the yellow and red portions vary. The hepatic cells of the yellow portion are swollen and cloudy, are granular, or are filled with oil globules. In fact, all these changes are observed in each case. The nucleus is pushed aside or displaced entirely, and in many instances masses of fat represent the cell. In a section vacuoles or vacant places are often observed, indicating the former seat of destroyed liver cells.

On section of the red part, an increase of the interlobular connective tissue may be observed, with an abundance of young connective-tissue cells. The liver cells that remain—most of them having been destroyed—are atrophied and shrunken, and become arranged in rows which simulate bile ducts in appearance. The embryonic tissue invades the lobule between the cells. The central vein is thickened and often surrounded by a young growth of connective tissue. The capillary bile ducts must to a large extent diminish or disappear with the destruction of the rows of liver cells. Pigment is observed among the cells in all instances, hæmatin crystals are abundant, and crystals of leucin and tyrosin are almost constantly observed. A definite increase in the connective-tissue elements may be observed. It is not limited to the red areas, although perhaps apt to be here more marked, and often has the appearance of considerable age; proliferation of the interlobular bile ducts is an almost constant feature. Distinct regeneration of liver substance has been described by Marchand in the case of a patient who died six months from the onset of symptoms.

The blood is dark and fluid, the spleen is enlarged and pulpy; the kidneys are enlarged, swollen, and congested. On microscopical examination, cloudy swelling, and fatty and granular degeneration of the tubular epithelium are seen. The heart is soft and flabby, and marked fatty and granular degeneration of the muscular fibres is found. In some cases the degeneration extends to the blood-vessels, and in various parts of the body the endothelium is found to have undergone fatty and granular degeneration. No special lesions of the brain have been observed. The cerebral vessels are markedly the seat of fatty degeneration of the intima; consequently hemorhages into the membranes and the brain tissue occur.

The mucous membrane of the stomach is congested and the seat of ecchymoses. The glands of the stomach and intestines are filled with granular and disintegrating epithelium. The stomach usually contains clotted or semi-coagulated blood. There is blood also in the intestines, in the lower part of which it assumes a tarry appearance.

In addition to the presence of ecchymoses in the gastro-intestinal tract, they are also seen in the skin and in the mucous membranes, in the pleura, the peritoneum and omentum, and in the brain and its meninges. The surface of the body and the mucous membranes are bile-tinged, and if a blister is applied, the serum is also bile-tinged.

The uterus, in cases occurring in pregnancy, either contains the fœtus or presents signs of a recent abortion.

The relation of the red to the yellow portion of the liver has been a subject of careful inquiry. It is now believed by most pathologists that the red is a later stage of the general process, because of its absence in the more acute cases, because it shows greater destruction of hepatic cells, because the yellow portion gradually merges into the red, and because it (the red) is more abundant in old cases. If this theory of the relation of the red to the yellow portion is accepted, the question of the nature of the primary hepatic change becomes more easily soluble. Is the process in the liver a pri-

mary fatty degeneration, or a general diffused hepatitis, the fatty change being secondary? The arguments mentioned above hold in a measure against the occurrence of diffused hepatitis as a primary affection; moreover, the degenerations in various other organs would point to a general origin of the disease, and not to a local diffused hepatitis. Then, too, the liver is a distensible organ, and its cells would not degenerate from the pressure exerted by the small amount of diffused new growth that is observed in acute yellow atrophy.

Symptoms.—The onset is gradual or sudden. In the former instance symptoms of gastro-duodenal catarrh may continue for two or three weeks, or even longer, before grave symptoms arise. In the latter, acute jaundice, accompanied by marked nervous phenomena, immediately ushers in an attack. The more protracted cases (the first class) present two varieties of symptoms, viz., prodromal and toxæmic. The symptoms of the prodromal stage are those of acute gastro-duodenal catarrh—headache, nausea, vomiting, loss of appetite, a bitter taste in the mouth, and general malaise. Diarrhœa may also occur. At the end of forty-eight hours or frequently after the lapse of some days, slight icterus appears and gradually increases in intensity. Bamberger states that in very rapidly fatal cases, it may occasionally be completely absent. Fever does not usually attend these symptoms. On the other hand, the pulse and temperature, as in jaundice, are often subnormal. The fæces are colorless, grayish, or parti-colored; often, indeed, they are quite natural. The normal appearance of the fæces in acute atrophy has led to the expression that such stools furnish an unfavorable prognostic element in jaundice, while the presence of clay-colored stools is a favorable sign. The urine contains bile pigment, and does not indicate the serious changes that are to ensue. Enlargement of the liver may occur. While the occurrence of this change is uncertain in acute yellow atrophy, it is a more or less regular happening in poisoning by phosphorus.

The toxæmic stage succeeds these prodromal symptoms more or less suddenly, and after varying intervals of time. The prodromal stage may be very short or quite protracted—even as long as three months. In some cases the toxæmic stage is announced by a convulsion or sudden profound coma. Legg insists on careful observation of the pupil in cases of jaundice, and declares that dilatation of it is the most significant indication of approaching cerebral symptoms. In others the typhoid state gradually supervenes, and is characterized by stupor, low muttering delirium, subsultus tendinum, incontinence of urine and fæces, restlessness, hiccough, motor and sensory paresis, with dilated, often insensible, pupils. A dry and brown, or fissured and glazed, tongue is present, sordes collects in the mouth, and the vomiting of the prodromal stage continues, though the character of the ejecta changes. "Black vomit" now occurs instead of the vomiting of a clear acid or greenish-yellow fluid. The black vomit is due to the presence of blood which has oozed into the stomach. Dark tarry stools indicate its presence in the intestinal tract also. Constipation, however, may be present.

The typhoid state terminates in deep coma, death being preceded by irregular or Cheyne-Stokes breathing, an irregular pulse, involuntary discharges, and sometimes by recurring convulsions. In some instances the typhoid type is not assumed, but active maniacal delirium attends this stage, with or without convulsions; coma or exhaustion closing the scene. Again, there is no delirium, but frequent and prolonged general convulsions occur, with local spasms in the interval and coma vigil. It is believed that the cerebral symptoms are due largely to hemorrhagic extravasation in the brain and its membranes. The blood dyscrasia, however, is probably an important factor. The brain symptoms have been attributed to uræmia, but the theory of such origin is not upheld by clinical facts. Austin Flint, Jr., thought they were due to cholesteræmia, while others attributed them to the presence of bile acids in the blood. Frerichs ascribed them to the presence of leucin and tyrosin in the blood, but experiments do not confirm his notion.

It is in this period that hemorrhages occur from mucous surfaces, as the nares, mouth, pharynx, stomach, and intestines. They also occur in the skin and into the serous membranes. They are due to changes in the walls of the capillaries and small blood-vessels, or, as some assert, to the altered blood. The hemorrhages are passive, and in the skin they are observed as petechiæ or vibices; in the external mucous membranes they appear as sordes or small clots. They may be seen in the conjunctiva. Litten describes hemorrhages in the retina. The constant oozing from the nares may seriously threaten life, while in females an abortion is almost always attended by a most profuse hemorrhage. When hemorrhages into the stomach and intestines have taken place, the discharges present a dark appearance, as indicated above.

The urine undergoes marked change. It is passed involuntarily, and wetting of the person is prevented with difficulty. Albumin, hyaline, epithelial and granular casts are present, from associated tubal nephritis. The urea is much diminished in quantity or entirely absent; phosphates and chlorides are also diminished. The urea is replaced by leucin and tyrosin, sarcolactic acid, peptone, albumoses, indicating less advanced or perverted tissue metamorphosis. The presence of leucin and tyrosin is not pathognomonic, and they may be absent (Murchison); there is a marked increase in the output of nitrogen owing to destruction of cells of liver and other tissues. The urine is usually acid, dark in color, and contains bile pigment. Contrary to their course in the prodromal stage, the pulse and temperature are increased in the toxæmic period. This is especially true of the pulse. It is increased in frequency, often excessively rapid, and not uncommonly irregular. The temperature range varies. In some cases there is no rise; in others the ascent does not occur until the last day or two of life, and may attain the highest point after death. My friend, Dr. H. M. Wetherill, of the Pennsylvania Hospital for the Insane, of Philadelphia, kindly permitted me to study the histological appearance of the various organs removed from a patient of his, who died of acute yellow atrophy of the liver. The case presented many interesting features, none more so than the temperature range. The patient, fifty-one years of age, was admitted into the insane hospital, for acute mania with delirium, on March 12th, 1885. She did not improve, and on April 9th had a "bilious attack," followed in three days by jaundice and urticaria. After the jaundice the maniacal delirium gave way to a low, muttering form. The icterus appeared on the trunk and arms first, and then extended to the entire surface. She lived nineteen days, and during the course of the disease had diarrhœa with pale, loose stools, and hemorrhages from all the mucous surfaces, petechiæ and vibices. The liver dulness decreased in area, and the splenic increased from day to day. The urine became albuminous, contained hyaline and granular casts, blood and bile pigment, leucin, and tyrosin. The urea became diminished in amount. The temperature range is indicated below. During the three days preceding the jaundice, when the patient was "bilious," a rise of temperature occurred. It then fell to normal and remained low until four days before death, when a continuous ascent began, reaching the acme, $105\frac{4}{5}$° F., thirty five minutes after death.

The pulse did not increase beyond 90. During the first, second, and third days of the illness it ranged from 82 to 90; from the fourth to the eighth day, inclusive, 76 to 82; and from the ninth to the sixteenth day the average daily range was 66. After the latter day it increased daily to the last day, when it was 86 (highest).

Along with the occurrence of cerebral symptoms and hemorrhages, changes take place in the liver and spleen. On physical examination the liver dulness is observed to decrease from day to day, and even may disappear anteriorly. One must be careful to remember that the flatulent distention of the intestines may cause apparent les-

Liver.

Day of illness.	Degrees, Fahrenheit.		Day of illness.	Degrees, Fahrenheit.	
	A. M.	P. M.		A. M.	P. M.
First	99.0	101.0	Eleventh	96.8	97.0
Second	99.4	100.2	Twelfth	97.2	97.0
Third	100.4	100.0	Thirteenth	96.6	96.8
Fourth	99.4	98.4	Fourteenth	97.0	97.2
Fifth	98.8	98.0	Fifteenth	96.8	96.8
Sixth	98.0	99.2	Sixteenth	97.6	98.4
Seventh	99.0	98.4	Seventeenth	99.0	99.4
Eighth	97.6	97.6	Eighteenth	99.4	100.2
Ninth	97.0	97.4	Nineteenth	101.6	101.8
Tenth	97.4	97.6	Twentieth	104.6	104.8*

* At 5:20 P.M. death.

sening in the area of hepatic dulness. It must also not be forgotten that the liver may be enlarged. The spleen, in a certain proportion of cases, is enlarged. Legg states that in one-third of the cases an enlargement is found at the autopsy. With the diminution in the size of the liver pain in the hepatic region is experienced. This may be extreme, entailing a great deal of suffering. It is most frequently seated in the epigastrium, and, as the changes are most marked in the left lobe of the liver, may be due to the atrophy. It is certainly a well-recognized fact that an agonizing pain attends acute yellow atrophy of the liver. Although attended by vomiting, the pain does not appear to have any relation to it. Marked tenderness in the epigastrium is associated with it in many instances.

The course of acute yellow atrophy of the liver varies. It is sometimes extremely rapid. Fifty per cent. of cases are fatal between the fifth and the fourteenth days; before the fifth day death is rare and is usually to be seen only in pregnant cases (Thierfelder). Cases of death have been reported to occur twenty-four hours after the first seizure. The toxic stage is much shorter than the prodromal; the latter usually continues for from one to eight weeks. The disease runs a more rapid course in pregnant women.

The PROGNOSIS is unfavorable, but not necessarily fatal. Cases of recovery have been recorded. In Wilks' celebrated case the patient recovered, and died two months afterward of a relapse. The case of Marchand (*vide supra*) shows that true regeneration of liver substance—and therefore recovery—is a possibility.

DIAGNOSIS.—The presence of the cardinal features of a case of acute yellow atrophy of the liver renders the diagnosis easy. The prodromal symptoms, the jaundice, the character of the urine, the nervous phenomena, the changes in the liver and spleen, and the hemorrhagic symptoms are to be kept in mind.

Care must be taken to exclude those forms of acute yellow atrophy which are due to phosphorus poisoning or to yellow fever, by attention to the antecedent circumstances and the history of the case.

TREATMENT.—The treatment can be stated in a few words. Some cures have been reported, and hence it is well to seek some methods of treatment. The indications that we can thus far discern are to relieve or cure the catarrhal symptoms as quickly as possible, and to allay the malignant symptoms of the second stage. The former is the treatment of gastro-duodenal catarrh or catarrhal jaundice. General principles guide us in the treatment of the latter.

John H. Musser.
Norman B. Gwyn.

[1] Revue de Médecine, 1886, vi., No. 4, 334-342.

LIVER, DISEASES OF: ANIMAL PARASITES.—The most important of the animal parasites of the liver is the echinococcus. Several others are occasionally found, but so seldom as not to justify the separate consideration of them. The round worm, for instance, migrates into the bile ducts and reaches the smaller tubes. The cysticercus cellulosæ is rarely found, and the same is true of the psorospermiæ. The pentastoma denticulatum and the so-called liver flukes, distoma hepaticum and distoma lanceolatum, are a little more frequent. The distoma hematobium is very rare except in North Africa. Other forms have been described under the names of distoma sinense and distoma conjunctum, but they may be regarded as curiosities.

The Echinococcus, or hydatid cyst, is a cystic disease of the liver due to the presence of the echinococcus polymorphus, the larval form of the tænia echinococcus; it causes a gradual enlargement and alteration of the form of the liver, and various functional disturbances both in it and in adjacent organs.

HISTORY.—In the works of Hippocrates,[1] Galen,[2] Aretæus,[3] and other ancient writers, references are made to large cysts of the liver containing water and, in some instances, numerous vesicles, which were undoubtedly hydatid in character; and in the literature of the sixteenth and seventeenth centuries we find many unequivocal references to the disease. The first accurate descriptions of the cyst are to be found in the "Sepulchretum" of Bonetus.[4] The parasitic nature of the disease was not known, however, until Pallas,[5] in 1766, discovered the parasite and showed its close relationship to the tapeworm. Götze, in 1782, determined that the scolices were the heads of embryonic tæniæ, and Bremser,[6] in 1821, described the disease as it occurs in man. The term echinococcus was introduced by Rudolphi, in 1801. The exact relationship of the echinococcus to the parent tapeworm, and the manner in which it invades the human body, remained hypothetical until Küchenmeister,[7] von Siebold,[8] and Leuckart[9] showed by direct experimentation that the hydatid is the larval state of the tænia echinococcus, which infests the alimentary canal of certain lower animals. The literature of the subject has been greatly added to by Davaine, Budd, Andral, Frerichs, Murchison, Heller, and Madelung.

ETIOLOGY.—Echinococcus of the liver is met with more frequently in Iceland than in any other part of the world. It has been estimated that every seventh person in that country harbors the parasite. Jonassen,[10] says, however, that this estimate is too high. No part of the world is exempt from the disease, but the statistics of its frequency in many parts are meagre. In the United States, and in most parts of Europe, it is comparatively rare. Lyon[11] was able to collect only 241 cases of hydatid disease in North America up to July 1st, 1901. Of these cases, 175 were definitely located in the liver.

The disease appears alike in both sexes, and at all ages, except during infancy. The wolf, fox, dog, and sheep are the most frequent hosts of the parasite. In Iceland it is generally attributed to the intimate relations which exist between the people and their dogs, the ova being conveyed no doubt in many instances by the tongue of the dog to the lips of his master; or they may be conveyed through contaminated drinking-water. In other countries the disease is probably more frequently acquired from infected meat or vegetables. Scolex-bearing cysts have been discovered in the livers and other tissues of the ox, sheep, hog, goat, deer, horse, squirrel, and many other animals. Richardson[12] attributes the frequent occurrence of the disease among the shepherds of Victoria, South Australia, to the eating of mutton, in the belief that the sheep have become infected from the shepherd dogs. Thomas[13] found at least forty per cent. of unregistered dogs, in various parts of Australia, infested. Heller[14] has suggested the possibility of auto-infection, on the supposition that the tænia may gain lodgment in the alimentary canal of man, although its presence there has not been demonstrated. Richardson's view is especially emphasized by Madelung in the Report of the Mecklenburg Physicians.[15] He shows that the dogs of Mecklenburg, where the disease is comparatively frequent, are not more numerous, do not come into closer contact with the people, and are not more generally infested by the tænia than in South Germany, where the disease is rarely encountered. Sheep, on the other hand, are more numerous than the people.

PATHOLOGY.—The tænia echinococcus is about 4 or 5 mm. ($\frac{1}{6}$ inch) in length, and consists of a head and three

segments (see p. 788 of vol. ii.). The head supports a rostellum bearing from twenty-eight to fifty-two rather blunt hooklets, arranged in two rows, as first recognized by Livois. The last segment is larger than the others combined, is endowed with both male and female generative organs, and, according to Leuckart, has the power to accomplish its own fecundation. This view is not, however, accepted by all investigators.

After fecundation has occurred the segment becomes filled with ova, estimated at about five thousand in number, each containing an embryo. As soon as the ova have become mature, the segment containing them becomes detached from the anterior portion of the worm, and is discharged from the intestinal canal of its host, either in its entirety or after it has been ruptured. Birth per vaginam is rendered improbable by the relatively small size of this channel. The ova reach the stomach singly, or in numbers, in the manner that has been described. Here the dense, sometimes calcified capsule is dissolved by the gastric juice, and the embryo is liberated. This is an oval, globular body, about three times as large as a human blood corpuscle, and armed at one extremity with six minute hooklets. From its point of liberation in the stomach or small intestine the echinococcus reaches the liver, either by boring directly through the intervening tissue, by penetrating a branch of the portal vein and being carried to the organ by the blood current, or by passing up the bile duct. Its migration, unlike that of the cysticercus or the trichina, is unattended by symptoms. Fortunately, the greater number of the parasites are destroyed before leaving the alimentary canal, and the cyst is usually single, but several cysts have occasionally been found in proximity. The cyst is usually located near one of the surfaces of the right lobe, but may be found in any part of the organ. When the embryo reaches the liver, it loses its hooks and acquires a vesicular form by the growth, from its caudal extremity, of a serous membrane which ultimately envelops it and becomes distended with fluid. It thus becomes the echinococcus cyst. The process by which this state is reached is in no sense pathological, but constitutes a period in the biological history of the parasite. The growth of the cyst is slow, years sometimes elapsing before it becomes large enough to create appreciable disturbances. When discovered, as in autopsy, it varies in size from that of a millet seed to that of the human head. The latter limit is rarely exceeded, but Leuckart records a case in which the cyst and its contents weighed thirty pounds.

The cyst is sometimes very delicate and of a gray color, sometimes thick and translucent, but usually it is only a little more dense than coagulated egg albumen. It is lamellated, consisting of a variable number of concentric layers, composed of a substance resembling chitin.[16] The inner layer, known as the parenchymatous or germinal membrane, is granular, and, according to Naunyn,[17] is provided on its inner surface with rapidly vibrating cilia. After a variable time, usually from two to five months, little mounds appear on the surface of the germinal layer, each of which has a small depression at its apex, which later becomes a vacuole-like cavity. These cavities then enlarge, and are known as daughter cysts. The process of budding may occur in the daughter cysts, giving rise to granddaughter cysts. Either generation may develop either endogenously or exogenously. The former method of growth is much the more common in man. The number of cysts formed varies from a few to several thousand. From the surface of the daughter or granddaughter cysts scolices, the heads of embryonic tæniæ, develop, either singly or in as great number as nine or more (Heller). These appear as conical projections, each having on its free extremity a rostellum, armed with a double row of hooklets and four suckers. The opposite extremity becomes constricted into a narrow pedicle, which later divides, liberating the scolex, thenceforth to float freely about in the interior of the capsule. The scolices and the brood capsules are endowed with the power of contraction, so that the heads may be protruded from the surface of the capsule or withdrawn; and after the head has become detached, it has also the ability to withdraw its anterior portion, with the rostellum and suckers, into the larger posterior part. Throughout the parenchyma of the scolex more or less numerous oval or spherical calcareous bodies are generally observed. Very rarely scolices develop directly from the germinal layer of the mother cyst. Küchenmeister[18] attributes this phenomenon to the invasion of what he designates the echinococcus scolicipariens, having from twenty-eight to thirty-six hooklets; while he designates the parasite which produces daughter vesicles the echinococcus altricipariens. This he describes as having from forty-six to fifty-two hooklets, and as sometimes present in the small intestine of man. His view has not, however, been generally accepted. Daughter cysts may develop also within the scolex, which then gradually becomes converted into a capsule.

In another variety of the disease the cysts remain sterile, no scolices being formed. These were first described by Laënnec, and were by him designated acephalocysts.

The multilocular echinococcus is a form of cyst which is encountered once in about one hundred and eighty cases of the disease. The sac, sometimes of very large size, is surrounded by an exceedingly dense fibrous capsule, firmly united to the surrounding tissue; is subdivided into numerous small cavities, and is filled with a thick, gelatinous, or colloid material, suggestive of cancer. Its real structure was demonstrated by Virchow.[19]

The echinococcus vesicles float in a limpid, usually clear, fluid, of neutral reaction, with a specific gravity of from 1.006 to 1.015. Sometimes, however, the fluid has a yellow or a pale green tint, and is slightly alkaline from admixture of bile, or is opalescent from the presence of fatty matter and other débris; or it may be a pale red from admixture of blood. Chemical analysis shows the presence of from 0.50 to 0.76 per cent. of sodium chloride, and small quantities of the earthy compounds of succinic acid, inosite, and grape sugar. Albumen is never present, except from the admixture of blood. Urea, creatin, and hæmatoidin[20] have occasionally been found, the last being considered peculiar to hepatic echinococci. Substances resembling toxalbumins and ptomaïns have been found by Maurton, Viron, and others. Cholesterin is found in cysts whose contents have undergone fatty degeneration.

As a result of the irritation produced by the echinococcus vesicle in the liver tissue, a firm fibrous wall is formed around it by a hyperplasia of the fibrous tissue of the organ, which extends also to the interlobular tissue for a variable distance around the cyst. This capsule is supplied with blood by vessels arising from the branches of the portal vein and hepatic artery. Old capsules frequently become more or less calcified (see Fig. 3221). As the cyst enlarges the parenchyma of the liver is, to a variable extent, destroyed.

The echinococcus sometimes dies, either spontaneously or as a result of accidents. Its growth is then arrested, and the cyst remains as a foreign body in the substance of the liver, its contents frequently undergoing retrograde changes and absorption, or calcification; or suppuration occurs, and the pus finds exit externally or through a neighboring viscus.

Symptoms, Course, and Termination.—Echinococci frequently exist in the liver for years without occasioning symptoms. The greater number of echinococci have been discovered post mortem. Only 7 out of 13 cysts, discovered in autopsy at Rostock, had been diagnosticated during life (Thierfelder); of 22 discovered at the Berlin Charité, 13 had been diagnosticated; and Madelung estimates that, outside of hospitals, only one-third of the cases are recognized during life.

In the majority of cases the first symptom to attract attention is the formation of a tumor, an apparent enlargement of the liver. The direction of greatest protrusion depends chiefly on the location of the tumor. If situated in the anterior portion of the right lobe, the hypogastrium is rendered prominent; if in the upper

portion of the lobe, it may push upward into the thorax, elevating the diaphragm, impeding respiration, often displacing the heart upward and to the left, and so compressing the right lung that the entire right side of the thorax yields a dull tone on percussion. It may also obliterate the intercostal furrows and even cause undue prominence of the chest wall. If situated in the lower portion of the lobe, the cyst may extend down to the pelvis; when it is in the left lobe, the epigastrium becomes prominent and the spleen may be displaced.

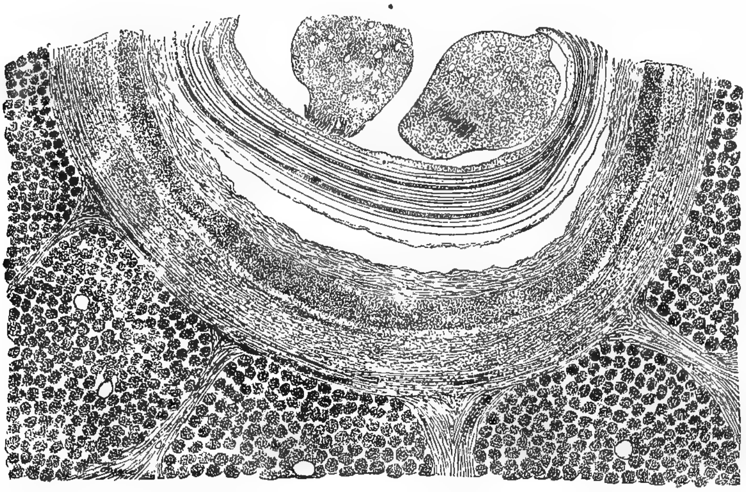

FIG. 3221.—Section of Echinococcus Cyst containing Two Scolices, in One of which the Rostellum is Protruded, in the Other Withdrawn. The firm capsule surrounding the vesicle shows a moderate degree of calcification. × 400. (From drawing of Dr. James M. French.)

If accessible to palpation, the cyst gives the impression of a smooth globular tumor, fluctuating as a rule, although not always, and frequently somewhat irregular in outline. If the tumor be of large size and contain many daughter vesicles, and if the abdominal wall be not too thick, we may, by grasping the tumor and exerting moderate compression with one hand, and striking a quick and pretty forcible blow upon it with the other, elicit a peculiar vibratory sensation—the hydatid purring of Briançon—which has been compared to the trembling of a bowl of jelly. By many this sign is considered pathognomonic, but it is absent in about half the cases, and has been elicited also in ovarian cysts and ascites.

Pain is an infrequent symptom. Bamberger states that some cases, up to a late stage, present no symptoms referable to the liver, while others are attended with more or less intense, undefined, pressing, or lancinating pains.

The pressure of a large echinococcus cyst upon adjacent organs produces symptoms which belong alike to all abdominal tumors of large size. Prominent among these are dyspnœa with cough, cardiac palpitation, indigestion, vomiting, constipation, and later ascites, œdema, and occasionally varicose veins. Unless the tumor be located in the immediate proximity of the portal vein or bile ducts, these vessels are not generally interfered with until late, when the growth has become large; jaundice is not, therefore, often present. There is usually no fever unless suppuration has occurred, and the nutrition of the individual, as a rule, is maintained. Suppuration of the cyst is announced by the development of pain and tenderness, and an elevation of temperature.

Rupture of the cyst occasions a new train of clinical manifestations, varied according to the direction in which the perforation occurs. Spontaneous recovery has followed evacuation through the abdominal wall, into the stomach or intestine, into the gall duct, the ureter, or the vagina. Rupture through the integument is generally preceded by "pointing"; rupture into the hollow viscera is followed by sudden intense local pain and the subsequent evacuation of a large quantity of fluid containing numerous vesicles. Rupture into the intestine or stomach produces a watery diarrhœa, and the tumor frequently becomes tympanitic from the admission of air. The entrance of bile into the sac causes death of the echinococcus and favors recovery. Rupture through the diaphragm into the pleural cavity causes severe pain and urgent dyspnœa. If death does not result promptly from shock or from violent pleuritic inflammation, the fluid may ultimately perforate a bronchial tube and thus find exit. The latter accident may prove fatal, either suddenly from strangulation, or in the course of weeks or months from prolonged suppuration, gangrene of the lung, and final exhaustion; or it may lead to recovery. It is signalized by a sudden expectoration of fluid, generally purulent or bloody in character, and containing echinococcus vesicles, entire or in fragments, and is commonly followed by a pneumothorax.

Perforation of the pericardium proves fatal immediately, or from acute pericarditis. After rupture into the peritoneal cavity death results from acute, generally violent, peritonitis.

In a few cases the inferior vena cava has been perforated, giving entrance to the vesicles and leading to instant death from embolism of the pulmonary artery. Perforation of the arterial system leads to embolism and its consequences.

The multilocular echinococcus is usually firm, rarely fluctuates, and is generally sensitive on pressure. It is frequently accompanied by enlargement of the spleen and ascites. Gastric disturbances are also more frequent than in the unilocular cyst, and jaundice is usually present. Gastric and intestinal hemorrhages and an effusion of blood into the subcutaneous tissues have occurred.

DIAGNOSIS.—Echinococcus of the liver is to be differentiated from cancer, amyloid infiltration, syphilis, cirrhosis, and abscess of the liver, and occasionally from hydro- or pyothorax, from cystic disease of the retroperitoneal lymph glands, from enlargement of the gall bladder, and from aneurism of the abdominal aorta. In the early history of the disease its differentiation from other tumors of the liver or its neighborhood is often very difficult. A tumor with the history of slow, painless growth, with elasticity, fluctuation, and the peculiar hydatid fremitus, is in all probability an echinococcus.

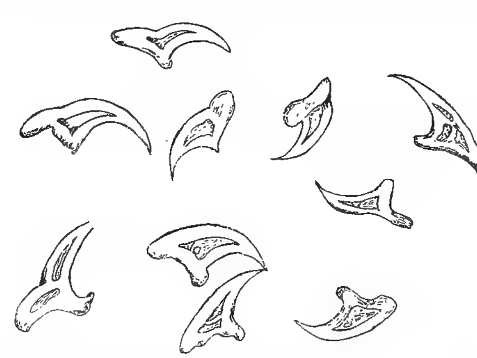

FIG. 3222.—Hooklets as found in Echinococcus Fluid. × about 750.

In every case, however, sufficient fluid should be withdrawn, through a small needle, to permit microscopical and chemical investigation. If the fluid be clear, limpid, free from albumin, of low specific gravity, and if it contain inosite, and succinic acid, there can be little doubt of

the hydatid character of the tumor. By the discovery of hooklets (Fig. 3222), and fragments of lamellated membrane, the diagnosis is established. But, unfortunately, many of these features are generally absent.

From cancer, the echinococcus may generally be distinguished by the absence of the lancinating pains, the tenderness, and the hard nodular surface of the latter, which is also frequently associated with a cachexia and cancer of other organs; from the medullary carcinoma, which has undergone softening, the distinction is often very difficult. The multilocular echinococcus can rarely be differentiated during life. From amyloid infiltration it is distinguished by the absence of the hardness, as well as of the history of prolonged suppuration and the wax-like hue of the skin that is characteristic of this affection. Syphilis must be excluded by the absence of evidences of present or past specific disease of the skin, mucous membranes, bones, and genitalia. In cirrhosis there are usually ascites and enlargement of the spleen, with the history of alcoholic excess and consequent gastric disturbances, which do not belong to echinococcus. Abscess of the liver usually follows an acute inflammation of the abdominal or pelvic organs, and is associated with acute symptoms, chills, fever, pain, and tenderness. An echinococcus which has elevated the diaphragm is distinguished from hydro- or pneumothorax by the course of the upper boundary of percussion dulness, which, in the echinococcus, is highest in the axillary line. Further, a pleuritic exudation is generally preceded by an acute attack of pain and dyspnœa, with fever and cough, and is frequently traceable to cardiac or renal disease, or to pulmonary tuberculosis; whereas echinococcus requires months, or even years, for its development, and by it the heart is pushed upward as well as to the left.

Cystic enlargement of the retroperitoneal lymph glands has rarely to be excluded; but in a case reported by Ransohoff [21] the liver was so compressed and its boundaries were so enlarged by a smooth, globular, fluctuating tumor that appeared to be a part of the liver, that the echinococcus could not be excluded until an exploratory incision had been made.

Enlargement of the gall bladder can be confounded only with a pendulous echinococcus cyst. Chemical and microscopic examination of the fluid is sufficient to establish the diagnosis.

Aortic aneurism can generally be excluded by its position and outline, as well as by its pulsation. Pean observed a case, however, in which an echinococcus cyst, as large as a child's head, rested directly upon the aorta in such a manner as to transmit a strong impulse.

An important point which arises in the differentiation of the echinococcus cyst, especially with reference to the adoption of operative procedures, is to determine whether the cyst is simple or compound, *i.e.*, whether the daughter vesicles have developed endogenously or exogenously. Occasionally the presence of two or more large and distinctly defined prominences will denote the presence of the latter variety, and the diagnosis will be established if, after withdrawal of the fluid from one cyst, the others remain distended. It may also be suspected in case the quantity of fluid which can be withdrawn from a large tumor by aspiration is relatively small. The case reported by Whittaker [22] is of interest in this connection. Here a large cyst protruded and was incised, the writer being present at the operation; the numerous smaller cysts found at the autopsy a few weeks later were not recognizable.

Prognosis.—The prognosis of echinococcus depends largely upon the size of the cyst and its location in the liver. If death of the parasite occurs, recovery is almost certain. If the cyst ruptures into a serous cavity, the prognosis is exceedingly grave; if into the vena cava, it is fatal; if into other vessels, it is usually so. Rupture into the intestinal canal, directly or through the bile duct, is, next to perforation of the abdominal wall, the most favorable route of exit. The prognosis of a living echinococcus in the parenchyma of the liver should always be considered sufficiently grave to warrant the adoption of measures for its destruction as soon as practicable after its discovery.

Prophylaxis.—This consists in the prevention of the contamination of food and drink by the ova of the tænia echinococcus. In Europe and America, where the domestic animals do not necessarily come into so close contact with their masters as in Iceland, and where greater attention is paid to cleanliness, the disease may be largely controlled. To this end, the public should be educated to the necessity of excluding dogs from those localities in which their fæces may contaminate the food and drink not only of man, but of sheep and cattle. Neither should dogs be allowed to eat the refuse or viscera of slaughtered animals, or, in fact, any uncooked flesh. All meats should be thoroughly inspected for the cysts, and should be thoroughly cooked before being eaten by man; and vegetables desired for raw consumption, as lettuce, celery, cabbage, and cresses, should be thoroughly cleansed and inspected before being placed on the table. Boiling is sufficient to destroy the vitality of the ova in either animal or vegetable food.

Medicinal Treatment.—The use of medicines in the treatment of this disease has been abandoned, for it is not believed that any drug can penetrate the dense capsule. When, however, we reflect that death of the echinococcus has occurred spontaneously, or as a result of the most trivial accident, we can readily comprehend how cures have been attributed to such remedies as potassium iodide, mercury, and various anthelmintic remedies or even to the application of salt solution.

Surgical Treatment.—Surgical measures are indicated, as a rule, as soon as the character of the growth has been recognized, for the chances of recovery are directly proportionate to the early destruction of the echinococcus. The methods employed are: (*a*) simple acupuncture; (*b*) puncture and aspiration; (*c*) electrolysis; and (*d*) free incision with subsequent drainage and irrigation.

Acupuncture has proved successful in a few cases. Aspiration has proved successful when only a small quantity of the fluid has been withdrawn, as well as after complete evacuation of the cyst. Its chief element of danger is the certainty with which suppuration follows its repetition. After the withdrawal of fluid by aspiration various substances have been injected for the purpose of destroying the parasite, but the practice is strongly condemned.

Electrolysis was originally proposed by Michon [23] and Althaus,[24] but was first extensively employed by Fagge and Durham,[25] who report eight successive recoveries from its use. The method consists in introducing into the most prominent part of the tumor two fine, gilded, steel needles, two inches apart, and both connected with the negative pole of a ten-cell battery capable of decomposing a saline solution. The positive pole—a moistened sponge electrode—is then placed on the surface and moved about over the hepatic region. The current is permitted to pass for about ten minutes. In the cases to which reference has been made, the immediate effect on the tumor was often a slight increase of size, owing to the disengagement of hydrogen gas. Constitutional disturbances were also produced in all but one case, the temperature ranging between 100° and 103° F. for from two to nineteen days. Later, however, the tumor diminished in size and finally disappeared, its absorption requiring from a few weeks to several months.

Incision of the echinococcus cyst may be performed by a continuous operation or at two sittings, inflammatory adhesion of the peritoneal surfaces being waited for in the interim. The method now generally adopted is that of first sewing the wall of the cyst to the abdominal wall and cutting between the sutures. The steps of the operation are the same as those adopted in opening a hepatic abscess and the dangers are no greater. Lihotzky [26] has reported twenty-five operations, four of which were under his own observation, with only four deaths, and three of these not attributable to the operation. Lihotzky's operations were all made by the two-sittings method, and

were all successful. Neisser[27] estimates the mortality at about one-third. Even if the latter estimate be correct, the operation is certainly indicated, at least after milder measures have failed.

Cases are sometimes encountered which require special methods of treatment, as when the echinococcus is attached to the liver by a pedicle, and has to be removed *en masse*.

The treatment of the multilocular echinococcus is wholly symptomatic. *James M. French.*

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4 Bonetus: Sepulchretum, lib. iii., Sec. 21.
5 Pallas: De Infestivis vivent. intra vivent., Diss. Inaug.
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23 Michon: Cited by Davaine, *op. cit.*, p. 596.
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25 Medico-Chirurg. Transact., 1871, p. 1.
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27 Neisser: Die Echinokokkenkrankheit, Berlin, 1877 (quoted by Lihotzky).

LIVER, DISEASES OF: CIRRHOSIS. (I. PATHOLOGICAL).—DEFINITION AND CLASSIFICATION.—Cirrhosis of the liver is a chronic disease caused by a diffuse overgrowth of the connective-tissue framework of the organ. Proliferation of the stroma may take place around abscesses, echinococcus cysts, gummata, foreign bodies, etc., in the process of their encapsulation, but the term cirrhosis is not applicable to such localized conditions.

Although all parts of the liver are affected in cirrhosis, the alterations may be more marked in some regions than in others.

Until recently it has been understood that the increased tissue must attain some degree of maturity before a cirrhosis could be said to exist; however, the direction of investigation, both clinical and pathological, has been toward a more thorough comprehension of the early symptoms and changes, and at present discussions, under the caption of cirrhosis, of conditions unaccompanied by any considerable overgrowth of the stroma, are by no means rare.

Without doubt the tendency of work in this direction will not only add to our knowledge of the etiology of cirrhosis, but will also extend the present limitation of the term cirrhosis, so that precicatricial stages in its development will, in the course of time, be included and form essential parts of the disease.

Numerous descriptions of cirrhotic livers occur in the writings of the earliest medical works under such names as hepar durum, obstructio hepatis, scirrhus, etc. According to Frerichs, Morgagni especially had clear notions of cirrhosis. There is no doubt that many cases of carcinoma and other tumors were included in the same category with cirrhosis by these ancient writers. That Laënnec, to whom the name cirrhosis is generally accredited, mistook the yellow projections on the surface for new formations, is a fact frequently referred to.

The subject of the classification of the cirrhoses is a favorite one, and at meetings of physicians prolonged endeavors to attain a unanimity of opinion are not uncommon. Many facts bear witness that the last and final contribution to this topic has not as yet been written. The co-ordination between anatomic changes and clinical symptoms has not been completed; the conception of cirrhosis, as before stated, is constantly being extended to cover earlier and other conditions than it previously applied to; within recent years new forms of cirrhosis that are distinct entities, at least from the standpoints of morbid anatomy and etiology, have obtained recognition; and lastly, it should be remembered that the capacity for regeneration possessed by the liver is quite remarkable. In the light, therefore, of what has already happened it cannot be considered surprising that other combinations of regeneration and inflammation than those at present recognized in the liver should in the course of time procure the dignity of separate consideration.

There is generally found in most classifications a group of so-called "mixed cirrhoses" which includes cases not readily disposed of under more exact names. The difficulty of dispensing with this group and its constant recurrence even in the writings of the best authorities furnish sufficient proof of both the inexactness of present classifications and of the variety of processes that may contribute to produce a cirrhosis of the liver.

The ideal and scientific classification—the etiologic one—has not gained much prevalence on account of difficulties in adjusting it to groups of symptoms and morbid changes; likewise the subdivisions of pathologists seldom meet with the entire approval of clinicians. Thus it has happened that the forms of cirrhosis usually mentioned are derived from two perspectives: those of etiology and of morbid anatomy.

Atrophic and hypertrophic cirrhosis are the generally accepted forms; fatty cirrhosis, pigmentary cirrhosis, Glissonian cirrhosis, a cirrhosis due to calculi and long-standing biliary obstruction, a cirrhosis caused by passive hyperæmia and the cirrhoses of tuberculosis, malaria, and syphilis have also been described. They have, however, fewer clinical and anatomic features than the two first-mentioned forms, which allow of their ready recognition either at the bedside or in the necropsy room. And yet, although their permanent taxonomic position is dubious, certain recent contributions indicate that some of them are entitled to more recognition than they have heretofore received.

ETIOLOGY.—The factors generally recognized as causative are alcohol, arteriosclerosis, syphilis, tuberculosis, malaria, passive hyperæmia, pigmentation with intrinsic or extraneous pigments, biliary obstruction, and the acute infectious diseases.

Of all factors alcohol, in the form of the stronger spirituous beverages and when used daily for long periods, is entitled to the most important place. Although the experimental production of cirrhosis of the liver in animals with alcohol by various observers (Straus and Blocq, Lafitte, Sabourin, Afanassiew, and others) has not been attended with uniform results, they have on the whole confirmed clinical observations. It is extremely doubtful if any animal experiments will equal in value the verifying evidence furnished by the numerous cases recorded of atrophic cirrhosis in children and even infants, to whom misguided parents have given daily drinks of beer or stronger liquors. The exact manner in which alcohol produces cirrhosis of the liver is not known. It has been supposed by some that alcohol alone will not suffice, but that, following its ingestion, substances are formed in the alimentary canal which so act on the liver that cirrhosis is brought about.

The frequent observation of a cirrhosis of the liver in animals, accidentally encountered in the course of routine laboratory experimentation, is in direct accord with the fact that it has been purposely produced in animals by a great variety of substances; in fact, "there are few diseases," Siegenbeek van Heukelom wrote in 1896, "that are in process of production in such divers ways by investigators."

Among the substances used are arsenic, phosphorus, silver, lead, antimony and other metallic poisons, chloroform, paraffin, butyric, valerianic, acetic and other organic acids; croton oil and carbolic acid. The toxins of

certain bacteria have been used, and Besançon used dead tubercle bacilli. Other investigators have employed vegetable alkaloids; for instance, Marckwald found that a cirrhosis followed the injection of antipyrin in frogs and rabbits.

From the organs of a guinea-pig that died without apparent cause Weaver isolated a bacillus belonging to the colon group, which, when injected into guinea-pigs, in doses not immediately fatal, caused a cirrhosis; bouillon cultures sterilized by heat caused similar alterations of the liver. Hektoen has produced a perilobular cirrhosis in guinea-pigs and rabbits by means of a bacillus of the pseudo-diphtheria group and also by cultures of the bacillus filtered through porcelain.

The above-named poisons, bacteria, and bacterial products have been administered with food, injected into the liver directly, or into the blood-vessels or body cavities.

The results of investigators in efforts to produce cirrhosis of the liver experimentally in animals have been varied; the production of cirrhoses which would serve as prototypes for those observed in man has been rarely accomplished. The results obtained by Boix with organic acids deserve special mention in this regard.

Kirkow has concluded, after a careful review of the literature, that degenerative processes and necrosis of the liver cells are not necessarily followed by cirrhosis, and that the important factor in the production of a cirrhosis is the repeated or continuous action of agents which produce such alterations—*i.e.*, agents which cause irritation.

In addition to such investigations with substances that act by destroying the parenchyma of the liver, efforts have also been made to produce cirrhosis by constricting the common bile duct or its branches, or by incomplete ligation of the main divisions or the branches of the hepatic artery or portal vein; the consequences of experimental hepatic embolism have also been studied.

Atrophic Cirrhosis.—This form of cirrhosis is the best and longest known; it is the commonest variety and has long enjoyed distinction under the names, "gin-drinkers' liver" and "hob-nailed liver"; it is also known as "Laënnec's cirrhosis" and "granular atrophy of the liver." In the liver it is the analogue of chronic interstitial nephritis or the "small granular kidney." The liver in this form of cirrhosis is lessened in size and weight; the diminution in size is often extreme in the left lobe, and this portion may appear simply as a short fibrous tag attached to the left border of the liver.

The weight is often reduced one-half and may be even less. The external surface, in place of the usual smooth and glistening appearance, possesses irregular rounded elevations that vary in size somewhat, but are distributed quite uniformly over all the exterior.

The elevations vary in color not only in different cases but also in the same liver; the presence of fat and the biliary pigments in different combinations produces tints of yellow and of yellowish-green or dark green. These elevations represent the remaining liver tissue, and some of them may correspond closely to the so-called adenomata or foci of nodular hyperplasia; to some extent, at least, most of these elevations on the external or cut surface represent efforts at regeneration on the part of liver cells and bile ducts.

Between the elevations there are furrows or linear and anastomosing depressions that are gray or reddish according to the embryonal or mature character of the granulation tissue composing them.

The elevations may be fairly uniform in size or they may vary from a barely visible size to that of a filbert; they are often best developed near the anterior margin or on the left lobe. That the contained liver cells are in a state of compression is rendered obvious by stripping off the capsule; the same fact is made apparent by sectioning the liver, when the islands of liver tissue are found projecting above the remainder of the cut surface. The liver is firm and cuts with increased resistance; the consistence may be like that of cartilage.

It is impossible to distinguish, on the cut surface, the "lobular markings" with any degree of certainty. It is not uncommon to see districts the seat of passive hyperæmia in which the "nutmeg appearance" of cyanotic atrophy is added to the changes caused by the cirrhosis. The histologic changes are as a rule confusing in that lobules are not readily found; difficulty is experienced in locating the central or intralobular veins, and lobules are often so cut up by bands of fibrous tissue that it may be impossible to locate their former limitations (Fig. 3223). It is not uncommon to find small groups of liver cells wholly within quite wide bands of fibrous tissue. As a rule, the liver cells are quite well preserved, although many may contain blood and bile pigments or may show signs of the former presence of fat droplets; occasionally fatty degeneration is very marked. The excess of connective tissue is most abundant about the portal vein radicles; in any well-developed case of atrophic cirrhosis there may be not only a large amount of fibrous tissue in these localities, but in other places there is also granulation tissue containing newly produced blood-vessels and accumulations of round cells, fibroblasts, and leucocytes. The vessels are outgrowths from the branches of the hepatic artery.

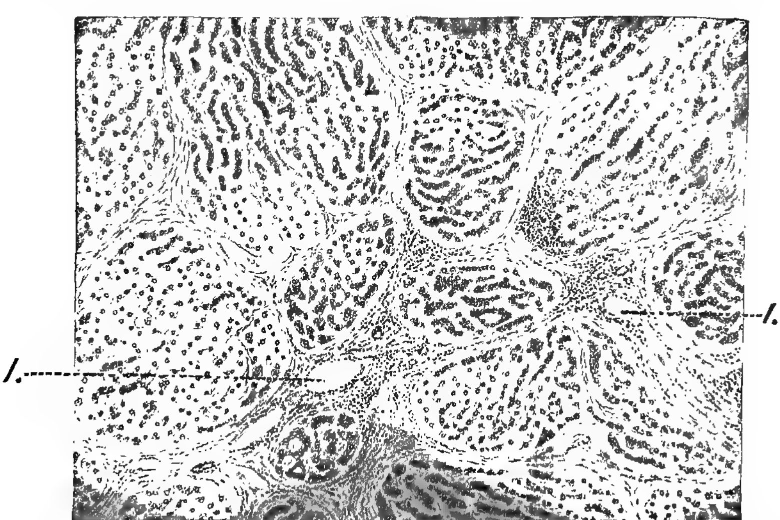

FIG. 3223.—Atrophic Cirrhosis. Great variation is shown in the size of the islands of liver cells and some are clearly too small to represent lobules (sublobular cirrhosis). At 1 are shown radicles of the portal vein. (Dr. Le Count's specimen.)

The occurrence of purely unilobular or of purely multilobular cirrhoses—the former with the increased tissue around each lobule, while in the latter it surrounds two or more lobules—is certainly quite rare; usually in any advanced case of atrophic cirrhosis the arrangement of the increased stroma is not limited to any single type. Flexner and his pupils and also Oliver have ascertained that both white fibrous and yellow elastic tissue are increased in amount in this form of cirrhosis (Fig. 3224). In the normal liver, according to Mall, there are three histological varieties of connective tissue serving as its stroma: the white fibrous, the yellow elastic, and reticulum; the last named existing chiefly within the lobules, while the yellow elastic tissue is to be found within and around the

blood-vessels. All three varieties may be increased in atrophic cirrhosis, but as concerns the reticulum the process seems to be an hypertrophy rather than an hyperplasia.

At the edges of the collections of liver cells representing lobules or portions of lobules and in the periportal newly formed connective tissue, there are present rows of cells that represent the attempt of the biliary channels to form new liver tissue. The continuity of some of these embryonic biliary canals with the older channels of the same kind has been proven by Ackermann, who succeeded in injecting them. It is also thought that some of them may represent a reversion of the liver cells to an embryonic type. Many of these rows of cells are continuous with the cords of liver cells.

There are certain sequential and incidental changes in other viscera and in other parts of the body that are more or less characteristic and constant accompaniments of atrophic cirrhosis and deserve consideration.

The spleen is usually enlarged and it may attain twice or even three times its normal size. This enlargement is usually ascribed to passive hyperæmia, and yet the claims of Oestreich are frequently quoted. From the study of a number of cases he was led to believe that the enlargement is mainly of an inflammatory character and that during the early stages of the cirrhosis the pulp of the spleen undergoes an hyperplasia which may persist, or later suffer induration or atrophy. Oestreich believes that the splenitis is due to the same irritants as those which produce the cirrhosis, and, like Ackermann, he is of the opinion that they may reach the liver by the arterial circulation.

The absence of valves in the portal vein and its branches facilitates collateral circulation, which, however, is seldom if ever completely established; and, in consequence of this, peculiar and interesting alterations result. The classical so-called "caput Medusæ" is perhaps of more clinical significance but certainly not more interesting than some of the more deeply seated disturbances of the circulation and blood-vessels, that owe their origin to a similar cause. The writer once met with multiple dilatations of the mesenteric veins in a necropsy held at the Cook County Hospital in Chicago, upon the body of a man who, previously to his death from atrophic cirrhosis, had suffered from numerous intestinal hemorrhages. The dilatations were located at the junction of the mesentery and bowel, were usually circular in contour, varied in size from a buck-shot to a small hickory nut, and were most numerous in the upper part of the bowel, decreasing in frequency toward the colon. Many of these had ruptured into the bowel and formed false diverticula; others were filled with dark blood or thrombi and looked not unlike a string of small grapes that formed a fringe to the intestine at its mesenteric attachment.

Dilated and tortuous veins occur in all the ligaments of the liver; in the round ligament a dilated vein is occasionally found as large as the finger. In the lower end of the œsophagus dilated veins are practically always present in marked cases of atrophic cirrhosis. Stockton, of Buffalo, has pointed out an important connection between ascites and the establishment of collateral circulation in that the latter may prevent the occurrence of the former. Such an influence of dilated œsophageal veins in compensating for the obstructed portal circulation has also been emphasized by Preble, who, in a valuable contribution to the literature of cirrhosis, analyzes sixty cases of fatal gastro-intestinal hemorrhage due to cirrhosis. He found that of these, only six per cent. showed ascites, enlarged spleen, and subcutaneous abdominal varices.

Icterus may occur with atrophic cirrhosis, and not only is the color of the liver thereby modified but the adipose tissue and lining membranes of the heart and blood-vessels are also tinted yellow.

Fibrous adhesions about the liver are not uncommon. Associated with ascites there are frequently œdema and serous atrophy of the subperitoneal and perinephric adipose tissue. Catarrhal inflammations of the stomach and intestines are also frequent in atrophic cirrhosis, and in the kidneys there is often found an interstitial inflammation comparable to that in the liver.

The diminution in length of the small intestine is a sequel to atrophic cirrhosis that many authors fail to mention; from the usual 7 to 8 metres, the length is reduced to 5 or 6 metres or even less. Gratia mentions one case in which it was reduced to 3.55 metres. The colon is also shortened and both large and small bowel undergo a diminution in calibre. The mesentery also becomes shortened. These changes in the alimentary canal and the mesentery are worthy of further investigation.

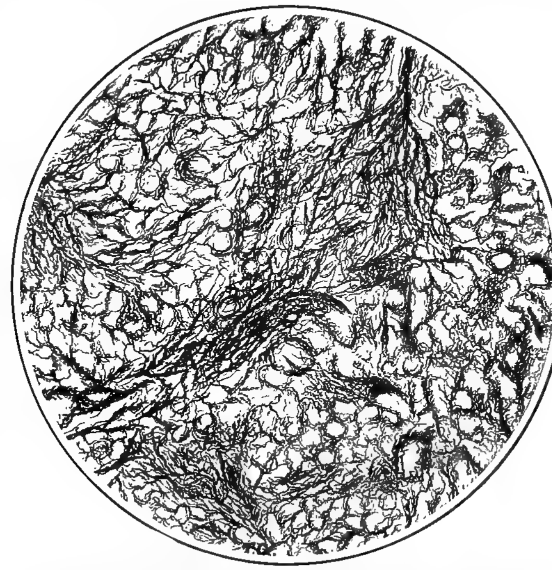

FIG. 3224.—Drawing from a Section of Atrophic Cirrhosis, after the Removal of the Parenchyma and Elastic Tissue by Digestion. Through the centre a vertical band of white fibrous tissue extends, and on either side the reticulum, which is also increased, is well shown. (From the collection of Dr. Oliver, of Chicago.)

Hypertrophic Cirrhosis.—On account of its infrequent occurrence and the fewer opportunities for studying it, less is known about this form of cirrhosis than about the preceding. According to Hanot hypertrophic cirrhosis occurs in young and feeble men, beginning with an attack of pain in the right hypochondrium and being associated with symptoms of disturbed digestion. After two or three such attacks jaundice appears and gradually increases. There are few other symptoms; attacks of indigestion and pain are accompanied by enlargement of the liver and spleen, and both viscera finally attain enormous sizes.

The liver weighs from 2 to 4 kgm.; it is finely granular externally, but on the whole it is smooth when contrasted with the liver of atrophic cirrhosis. Fibrous adhesions may exist, binding it to the diaphragm, peritoneum, or neighboring viscera. The size of the liver causes displacement of the costal arch and ribs on the right side forward and outward, and an increased width of the lower part of the thorax. Its lower margin is often to the left of the umbilicus and below, and in contact with the crest of the ilium on the right side. The color of the organ is usually yellowish-green or dark olive green or mottled with patches of both. The biliary channels are all patent, so far as the gross examination goes. The lobular markings, viewed externally or on the cut surface, are obscure or indistinguishable and in their place are innumerable small, rounded, and irregular elevations; occasionally these are not at all striking and both the external surface and that exposed by sectioning may be quite smooth. The consistency of the liver is increased.

While the changes in the minute anatomy of the liver are quite different from those ordinarily found in atrophic

cirrhosis, it would nevertheless be hazardous in all cases to attempt to distinguish the two forms of cirrhosis from one another by the histologic alterations alone; occasional examples would prove very puzzling (Fig. 3225). In typical instances the limitations of the lobules may be located by the interlobular vessels and bile ducts, although some difficulty may be experienced in finding all the familiar landmarks. The most marked characteristics are the remarkable proliferation of the bile ducts, the radially arranged growth of connective tissue from the peripheries toward the centres of the lobules, the failure of the portal veins to become involved in the granulation tissue, and the general absence of perilobular hyperplasia of the stroma. The borders of the lobules are notched primarily to an infection that invades the liver by way of the bile ducts.

The enlargement of the spleen, which may reach a weight of 1 kgm. or more, is due to an hyperplasia of the lymphoid tissue. The general nutrition is maintained for a long time in this form of cirrhosis, cachexia rarely appearing until the disease has been established for several years. Ascites, if present at all, makes its appearance toward the end; it may be entirely absent and is never considerable in amount. The entire course of the illness may extend over a period of from five to ten years.

Obstructive Biliary Cirrhosis.—The extrahepatic ducts may be obstructed in various ways. Following the gen-

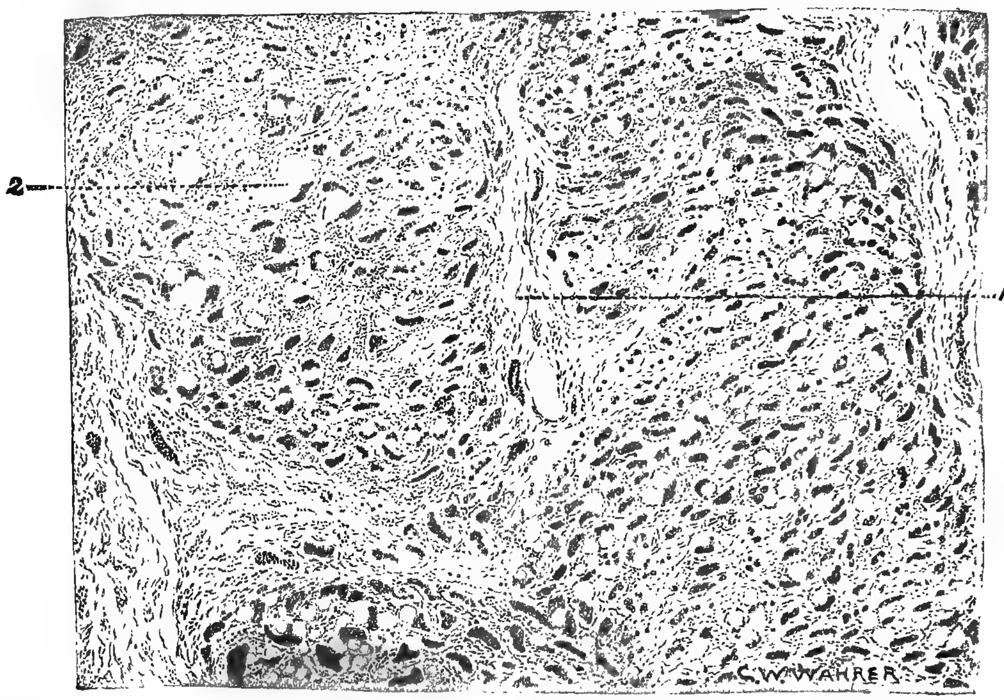

FIG. 3225.—Hypertrophic Cirrhosis. The band of tissue shown at 1 is interlobular connective tissue; there is a lobule to the right of this and one to the left; at 2 is the central vein of the latter, and below 2 are numerous small groups of liver cells isolated from the main part of the lobule by intralobular extension of small bands of embryonal connective tissue. (Dr. Le Count's specimen.)

with small processes of connective tissue which, extending into the lobules, separate more or less completely single liver cells or groups of them from their respective cords and columns. Such isolated liver cells often contain bile pigment in rounded and club-shaped masses or branching plugs moulded to the shape of the biliary canaliculi. These isolated liver cells are directly continuous with the newly grown bile ducts. These last formations are very numerous, and from the small size of some of them it is difficult to believe that they possess distinct channels. Around the larger bile ducts there are both the mature and the hyaline forms of connective tissue, in excess of the normal amount, and also granulation tissue and collections of leucocytes (Heineke). The liver cells are but slightly altered; the great increase in size and weight of the organ, it has been suggested, may be due to an increase in the parenchyma; be this as it may, it is certain that hyperplastic cirrhosis would be a more appropriate name than the one in present use.

The etiology of this form of cirrhosis is not definitely known, but there is a general disposition to connect the process with the pericholangitis which constitutes such a conspicuous feature of its minute anatomy. The view at present held by the French school of pathologists is that hypertrophic cirrhosis, or Hanot's cirrhosis, is due eral law that the parenchyma of the gland disappears when its excretory canal is closed, cirrhosis of the liver takes place as an accompaniment of atrophy of the gland tissue proper. Such cirrhoses may follow congenital absence, malformation, or occlusion of the bile ducts. Death occurs before any considerable shrinkage has taken place, for the livers of such infants are found greatly enlarged, firm, deeply jaundiced, granular externally, and quite resistant to the knife.

Histologic examination reveals an interlobular cirrhosis with extensive formation of embryonic biliary channels. It is not known whether the cirrhosis is due to the obstruction to the outflow of the bile or to the same causes that produced the malformation of the ducts in these cases.

That cirrhosis would ultimately occur is borne out both by experiments upon animals and by the cases reported in which cirrhosis affected one lobe in which calculi have been found obstructing the corresponding branch of the hepatic duct.

Ford has collected the cases of obstructive biliary cirrhosis that have accumulated in medical literature since the compilation of Mangelsdorff in 1882. He was able to find twenty-one and to these he added three.

As concerns the pathological anatomy and histology of this form of cirrhosis, there is less to mark it as a distinct

form than is found in the etiology and clinical course of the affection. The liver may be greatly enlarged or it may approach in size and appearance the ordinary atrophic cirrhosis; it should be remembered, however, that, in the latter, icterus is usually absent entirely or at least is not marked; whereas in obstructive biliary cirrhosis the liver will be deeply pigmented. A further difference in the morbid anatomy is afforded by the occurrence of numerous biliary retention cysts in the obstructive form; these are usually small, rarely larger than a pea, frequently smaller, and contain dark green or inspissated bile. In this form of cirrhosis the extrahepatic ducts are dilated and in any given case the obstruction might be still demonstrable.

The liver is often found enlarged in obstructive biliary cirrhosis, and in two of those considered by Ford (one reported originally by Boinet) it weighed over 4 kgm. It is hard, rough externally, and adherent to the surrounding structures.

It is cut with difficulty and, in addition to the retention cysts mentioned, the cut surface shows an increase in connective tissue. If the cases did not run such an acute course it is likely that the resemblance to Laënnec's cirrhosis would prevail in all cases; as it is, however, there is a great similarity to the hypertrophic biliary cirrhosis of Hanot. The appended table, taken from the article by Ford, illustrates well the differences between the two as well as some further analogies between obstructive biliary cirrhosis and atrophic cirrhosis. There is no doubt that this form of cirrhosis is worthy of consideration as a distinct morbid entity.

Symptoms.	Hanot's cirrhosis.	Obstructive cirrhosis.
Course of disease	Chronic	Acute.
General health	Good	Poor.
Emaciation	Slow	Rapid.
Loss of weight	Slow	Rapid.
Intermission of symptoms.	Common	Does not occur.
Fever	Common	Rare.
Anorexia	Rare	Common.
Good appetite	Common	Rare.
Vomiting	Rare	Common.
Jaundice	Slight at first, increasing.	Deep from the first.
Clay-colored stools	Rare	Constant.
Bile-stained urine	Common	Constant.
Enlargement of liver	Common	Common.
Contraction of liver	Rare	Common.
Ascites	Rare	Common.
Œdema of extremities	Rare	Common.
Caput Medusæ	Rare	Common.

Pigmentary Cirrhosis.—In 1891 Welch described a condition of cirrhosis due to the presence of particles of coal. Numerous small black specks and streaks were visible both externally and on the cut surface; they were scattered at irregular intervals of not more than 0.5 to 1 mm.; around many of them the liver possessed a grayish color, although the prevailing color was yellowish-brown.

The chemical examination of the pigment revealed no difference between it and the coal pigment found so commonly in the lungs and bronchial lymph glands. The histologic examination showed, as the prevailing condition, the presence of rounded masses of fibrous tissue averaging from one-sixth to one-eighth the diameter of a liver lobule; they were located most frequently in the interlobular tissue and were composed of dense fibrous tissue. These fibrous patches were also found within the lobules and surrounding the central veins; they were so numerous that with low powers of the microscope many were seen to be present in any single field. They all contained large amounts of black coal pigment.

The cirrhosis differed greatly from any of the ordinary forms in the circumscribed and focal character of the lesions.

Welch named the condition "cirrhosis hepatis anthracotica," and references to his description are often met with in the literature of cirrhosis of the liver. As an etiological and pathological entity this variety deserves recognition.

Another form of cirrhosis due to deposits of pigment has attracted considerable attention within recent years, and it possesses the merit of manifesting clinical characteristics, in addition to etiological and pathological features, that serve to distinguish it; it is the pigmentary cirrhosis of bronzed diabetes.

In a necropsy held by me in the Cook County Hospital upon a case of this character the liver weighed 2.7 kgm. and was at once remarkable for its color, a yellowish-brown or ochre-yellow—a pigmentation never simulated by the biliary pigments. There were no tints of green present. The liver had preserved its form; the external surface was finely granular; the consistence markedly increased; and, on the surfaces exposed by sectioning, the lobules were plainly distinguishable, projecting slightly above the surface and surrounded by reddish or darker-colored sunken stroma. The gall bladder was distended by thick dark bile and the ducts were patulous.

This case has been reported in full by Condon, and at the time of its publication it was the third necropsy upon this form of cirrhosis recorded in America. The liver in the case reported by Opie answered to a very similar description, as will be seen by the following:

"Weight 2,270 gm. The surface is of a deep reddish-brown color of a peculiar character, resembling that of iron rust. The surface of the left lobe, more markedly than that of the right, is superficially nodular and puckered, presenting in moderate degree the appearance of a hob-nail liver. On section islands of lighter brown parenchyma, representing one or several lobules, are surrounded by fibrous stroma of a deeper brown color. Sparsely scattered are opaque yellowish-white areas, often 1.5 mm. across. The gall bladder, distended by thin green bile, measures 12 cm. in length."

The histological changes in this form of cirrhosis are truly remarkable on account of the excessive amount of hæmatogenous pigment present everywhere. The points where it is accumulated in greatest amount are in the fibrous tissue, but large amounts also occur in the liver cells, in the endothelial cells of the capillaries, and in Kupffer's cells; it is also found entirely free. Newly formed bile ducts occur in the cicatricial tissue as well as in embryonal blood-vessels. The perilobular type of cirrhosis is followed for the main part, but the groups of segregated liver cells are often smaller than lobules.

Whatever may be the final outcome of the present speculations as to the relationship between the generalized hæmochromatosis, the diabetes, and this form of cirrhosis,—for all three usually occur together,—it is proper to consider this form of cirrhosis a distinct type of disease of the liver in its pathogenesis, morbid anatomy, and histology.

A most thorough review of the entire subject has been made by Anschütz; in it he analyzes twenty-four cases. Different theories have been advanced by the different writers. One view is, that the diabetes is primary, and that hæmolysis and pigmentation, with interstitial inflammations in various viscera, occur secondarily; some of the adherents to the foregoing theory believe that the pigment is formed where it is found, while others maintain that it is deposited there subsequently to its formation. Other writers have advanced the proposition that the hæmolysis is primary, the diabetes resulting from pigmentary cirrhosis of the pancreas, and the cirrhosis of the liver from the deposition of pigment there. "It may be stated that the deposition of pigment in the liver is now universally regarded as the existing cause of the liver changes" (Futcher).

A cirrhosis due to pigmentation has also been described in malarial infections; but, since considerable pigmentation may take place without any marked cirrhosis in malarial infections of a chronic type and in malarial cachexia, the origin of the cirrhosis occasionally met with has been questioned. The pigment is deposited in the endothelial cells and in Kupffer's cells, but is rarely found within the liver cells; and since a prerequisite for the development of a cirrhosis seems to be a destruction of the parenchyma cells, a cirrhosis of the liver due to

the deposition there of pigment formed during malarial infections may justly be considered rare.

Other Forms of Cirrhosis.—Certain other forms of cirrhosis possess a distinct etiology and some a definite histology, but few of these at the same time have associated syndromes or morbid anatomy that would permit of their recognition either clinically or at post-mortem examinations. An exception to this statement perhaps occurs in the coarsely nodular cirrhosis due to syphilis, which in some instances is associated with gummata.

The cirrhosis of congenital syphilis has been described as diffuse and "pericellular" in type. The cirrhosis caused by long-standing passive hyperæmia, which is in reality much more uncommon than is generally supposed, possesses a distinct histology; this was well illustrated by a case studied in the Pathological Laboratory of Rush Medical College by Mr. Dryer, whose report was embodied in the article by Herrick on "Pericarditic Pseudo-Cirrhosis of the Liver."

The liver weighed 2,235 gm., and, aside from the very evident cirrhosis, showed miliary tubercles and foci of nodular hyperplasia. Although, in the gross inspection of the liver, there were no signs to indicate the pathogenesis of the cirrhosis, the study, by serial sections, of the minute anatomy revealed the fact that the proliferation of connective tissue was most marked about the central veins, and that from here the lobules and interlobular structures were involved.

The descriptions of Parmentier do not make it apparent that "cirrhose cardiaque" could be easily recognized from its gross anatomy alone.

The termination of acute yellow atrophy in "multiple nodular hyperplasia" has afforded opportunity for many publications and lengthy discussions; for the most part they have been directed to the relationship of the so-called "adenoma" formations to tumor growth, rather than to that which such processes of regeneration bear to cirrhosis.

Finally, there is mentioned in some text-books a form of cirrhosis, "Glissonian cirrhosis," that has been supposed to have its origin in a perihepatitis.

The insufficient grounds upon which such ideas have rested is well shown by Nicholls in his recent monograph on "Chronic Inflammation of the Serous Membranes." After a careful consideration of all the published cases of chronic perihepatitis ("Zuckergussleber") Nicholls writes: "Our recorded cases clearly prove that cirrhosis of the liver is by no means a frequent accompaniment of hyaline perihepatitis." *E. R. Le Count.*

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LIVER, DISEASES OF: CIRRHOSIS. (II. CLINICAL). —The classical division into two classes: (1) Portal cirrhosis (synonyms: Laënnec's cirrhosis, hob-nailed liver, atrophic cirrhosis) and (2) biliary cirrhosis (synonyms: Hanot's cirrhosis, hypertrophic biliary cirrhosis) will be preserved here, but with the distinct explanation that the clear-cut distinction which the two terms seem to imply cannot always be made out, as the symptoms of the two varieties run into each other almost inextricably in many of the cases. However, the two classes named above enable us theoretically better to understand the disease.

1. Portal or Atrophic Cirrhosis.—The symptoms of the first stage are not at all characteristic of the disease, but are due to the action upon the stomach and intestines of the most frequent cause of the hepatitis, *i.e.*, alcohol. There may be morning retching or vomiting, with discharge of mucus, in conjunction with other symptoms of gastric catarrh, such as loss of appetite, nausea, sensations of weight and distention after meals, gaseous eructations, disagreeable taste in mouth, temporary and slight elevations of temperature, irregularity of the bowels,—at one time costive, at another time loose,—a tendency to hemorrhoids, etc. Perhaps a slightly yellowish color of the conjunctivæ may be noticed from time to time. Examination may elicit tenderness in the epigastrium and sensitiveness over the liver, which by percussion and palpation may be found somewhat enlarged. These symptoms are obstinate, and yield only slightly to treatment, and when such is the case in a person who has for a long period of time been addicted to alcohol, our suspicions may be aroused as to the presence of cirrhosis of the liver in an early stage.

The second stage, as the morbid process in the liver progresses, presents a very definite train of signs and symptoms which are due to (1) the portal obstruction, and (2) the impairment of the hepatic function brought about by the destruction of the liver cells.

1. The obstruction to the portal capillaries, so soon as the collateral circulation is not sufficient to carry the portal blood to the heart, produces serious symptoms. There is a chronic hyperæmia of the gastro-intestinal tract causing an intensification of the already existing gastric and intestinal symptoms (as above). Ascites makes its appearance in at least eighty per cent. of the cases, and it may be the first symptom noticed by the patient. It is usually slow in development, but may assume enormous proportions so soon as the collateral circulation becomes inadequate to carry the portal blood to the heart. This collateral circulation is given by Osler as follows: "1. The accessory portal system of Sappey, of which important branches pass in the round and suspensory ligaments and unite with the epigastric and mammary systems. These vessels are numerous and small. Occasionally a single large vein (parumbilical) or several smaller ones may run from the left division of the portal vein, in the round ligament, alongside the obliterated umbilical vein, to the umbilicus, where they communicate with the epigastric system. There may be produced about the navel a large bunch of varices: the so-called caput Medusæ. Other branches of this system

occur in the gastro-epiploic omentum, about the gall bladder, and, most important of all, in the suspensory ligament. These latter form large branches, which anastomose freely with the diaphragmatic veins, and so unite with the vena azygos. 2. By the anastomosis between the œsophageal and gastric veins, the veins at the lower end of the œsophagus may be enormously enlarged, producing varices which project on the mucous membrane. 3. The communications between the hemorrhoidal and inferior mesenteric veins. The freedom of this communication is very variable. 4. The veins of Retzius, which unite the radicles of the portal branches in the intestines and mesentery with the inferior vena cava and its branches, to which system belong the whole group of retroperitoneal veins. Œdema of the legs and feet, of the external genitals, and of dependent parts of the abdominal walls is frequent in the later stages of the disease, and is due to the pressure of the distended abdominal contents upon the veins coming from the lower extremities, as well as to the enfeeblement of the general circulation, and malnutrition of the patient."

Hemorrhages may take place from the gastro-intestinal tract at any time, either from the stomach or from the intestine. The smaller ones are probably due to the bursting of congested capillaries. Larger hemorrhages are due to the ulceration or rupture of one of the varicose, dilated veins lying in the cardiac end of the stomach and the lower part of the œsophagus. The hemorrhage may be very profuse and quickly fatal. Epistaxis and cutaneous hemorrhages may occur later in the disease. Hemorrhoids are frequent and readily bleed. The gastro-intestinal hemorrhages often give temporary relief to the digestive disturbances. Pain and tenderness over the region of the liver and spleen may also be complained of at various times, and these attacks are doubtless due to attacks of local peritonitis. Pain may also be referred to the angle of the scapula, and to the tip of the right shoulder. An adequate explanation of these referred pains cannot be given at the present time (Schaefer). There is no fever in this variety of cirrhosis, and when present, it is due to complications. The spleen is enlarged in all but one-quarter of the cases, and is probably caused by not only the portal obstruction, but also by the absorption of toxins from the intestinal tract.

2. Symptoms referable to disturbed hepatic function. In pure portal or atrophic cirrhosis jaundice is not the rule, and, if present, is usually light and due to the duodenal catarrh. Digestive disturbances become more extreme, and malnutrition and loss of flesh and strength are pronounced. The patient becomes nervous and irritable. The heart's action is enfeebled, the respiration labored and accelerated, in part from the elevated condition of the diaphragm due to the abdominal distention. The urine is often diminished in amount, and presents an abundance of urates and sometimes bile pigment. The urea may be found decreased. Albumin and casts indicate coincident disease of the kidneys. In rare instances it may contain sugar. The condition of the blood is not characteristic. There is no increase in the leucocytes, no extensive diminution either of the hæmoglobin or of the number of the red corpuscles, but epistaxis and petechiæ in connection with the general, as opposed to the portal, circulation would seem to indicate that the blood is either of poor quality, or else contains toxic substances capable of producing degeneration of the capillary walls. The occasional occurrence of œdema preceding ascites is another indication of this toxic or impoverished condition of the blood.

Physical Examination.—There may be a faint, and perhaps recurrent, yellowish tint of the conjunctivæ and skin, or this latter has an earthy, ashen look, and is dry and scaly, often with eruptions. The venules on the nose and cheeks are distended. The face assumes a characteristic appearance. It is thin, the eyes are sunken, and the malar bones are very prominent. The tongue is dry and coated. The distended abdomen contrasts sharply with the greatly emaciated chest. The navel protrudes, and the superficial capillaries and veins are prominent (caput Medusæ). Œdema of the extremities is likely to appear. The physical signs of ascites are usually typical. There may be some tenderness over the liver and spleen. These two organs may not be palpable until paracentesis is performed, when the liver may be found moderately enlarged (in the early stages or when combined with fatty infiltration), or, what is more characteristic, small, hard, nodular, and contracted. The edge of the spleen is readily felt, and the organ may be doubled or tripled in size, and is dense. There may be a systolic functional murmur at the apex of the heart, and a venous hum in the epigastrium.

Complications may coexist and give appropriate physical signs and symptoms, such as pleurisy with effusion, emphysema, endocarditis, myocarditis, pericarditis, arteritis, cirrhotic nephritis, chronic pachymeningitis, tuberculosis, peripheral neuritis, thrombosis of the portal vein, etc.

Course, Duration, and Prognosis.—After ascites or hemorrhages have made their appearance, the course is usually rapid, and the end is reached within a year. In many cases the course may be protracted over a long period, or even altogether arrested in a few cases, if the diagnosis be made early, the causes avoided, and the treatment initiated before the alterations have become considerable. Death usually results from intercurrent disease or from progressive exhaustion. In not a few cases cerebral symptoms occur suddenly — delirium, stupor, convulsions, coma, and death.

2. Hypertrophic Cirrhosis.—This so-called biliary cirrhosis is a distinct disease, and in typical cases presents many points of marked contrast with the preceding variety. In the first place, while in the majority of cases there is a definite history of hard drinking, yet from the fact that in other cases there is no such history, we must conclude that alcohol is not always the immediate cause. There is increasing evidence in favor of regarding this form as definitely of infectious origin. There is often a history of gall stones, or of obstruction of the duct from other causes. Then, again, the greater number of cases occur in young adults. The early symptoms do not amount to more than a general failure of health, loss of appetite, slight weakness, and perhaps a sensation of weight in the right hypochondrium. The onset of jaundice is often the first real symptom. With this there is frequently a series of attacks of pain in the region of the liver, with tenderness, and with each of these attacks the jaundice becomes more marked. Jaundice increases and persists throughout the course of the disease. The number of leucocytes in the blood may be found increased. The abdomen enlarges, as a result of the increased size of the liver, whose surface is smooth and indurated. The liver remains large throughout the disease and does not contract. The jaundice is commonly intense, but bile is very rarely absent from the stools. Ascites and hemorrhages are either entirely absent or else slight. There are no evidences of portal obstruction. These patients are liable to severe attacks of gastro-duodenitis with jaundice, attended with fever and cerebral symptoms. These attacks are often fatal. Enlargement of the spleen is very common throughout the disease. The occurrence of fever is an important feature of the disease, being thus unlike portal cirrhosis. There is often an afternoon rise of temperature which, during the severe attacks, may run high, to assume a hectic type suggestive of hepatic abscess or pylephlebitis. These attacks behave like a bad obstructive jaundice, although the hepatic and common bile ducts are pervious. The patients have pain over the liver, vomiting, constipation, intense and increasing jaundice, high fever, emaciation, rapid pulse, delirium, convulsions, coma, and death.

The *prognosis* is unfavorable, but yet in many cases the course of the disease is slow, and in some it is arrested altogether, the patients having no symptoms, although the cirrhosis still exists.

The *diagnosis* is often difficult. Gradual and continued jaundice without cause, continuing for a long time, associated with persistent enlargement of the liver and spleen

without symptoms of portal obstruction (absence especially of ascites and gastro-intestinal hemorrhages), and occurring particularly in a non-alcoholic subject, points with some degree of certainty to hypertrophic cirrhosis of the liver. It must not be forgotten, however, that in portal cirrhosis severe jaundice may exceptionally be found, and that ascites and gastro-intestinal hemorrhages may likewise exceptionally occur in biliary cirrhosis; consequently in some cases it may be impossible, because of the inability to distinguish which of the two varieties lies before us, or whether both forms do not exist together, to say more than that a cirrhosis of the liver is present.

Treatment—1. *Medical Treatment.* We will consider the two varieties of cirrhosis together. We must in the first place endeavor to ascertain and treat the cause of the cirrhosis. In all cases alcohol must be strictly avoided, as well as irritating articles of food, such as spices, coffee, etc. A malarial patient should be removed to a non-malarial climate. The syphilitic patient should be given inunctions of mercury and large doses of potassium iodide. Secondly, we have to treat whatever produces impairment of health and a tendency to death, so far as lies in our power. The diet should be plain, simple, but ample for the maintenance of strength. Chronic gastritis is to be treated in the usual way, *i.e.*, by prescribing a milk diet for a time if the disturbance of the digestion be severe, then a careful regulation of the diet, all forms of starchy and saccharine food being reduced to a minimum to avoid fermentation and flatulence. Green vegetables and fruit (potatoes being avoided), beans, peas, eggs, boiled fish, and fresh lean meat may be eaten if well borne; so also may stale bread, especially Graham bread. Lavage of the stomach will be found indispensable in most of the cases. Plenty of fresh air and moderate exercise should be secured. The patient should avoid nervous anxiety and fatigue and be carefully protected from cold and wet.

Certain drugs may be found useful. Bitter tonics and acids may stimulate the appetite, and the milder preparations of iron may be used to overcome anæmia. Potassium iodide may be given with the slender hope of preventing further formation of connective tissue. Chloroform water, bismuth, and magnesia are of use for the nausea and vomiting induced by the catarrh of the stomach, while bismuth, salol, thymol, and peppermint water are to be recommended for the relief of flatulence. The bowels are to be regulated by salines, rhubarb, aloes, or calomel. Except in the later stages of the disease, or when hemorrhage takes place, diarrhœa, if not too profuse, need not be checked by medicine. If this be necessary, bismuth subnitrate, the mineral acids, krameria, catechu are perhaps the most efficient. These patients do not bear opium well. Hemorrhage from the stomach or intestines is best relieved by ice, morphine, and absolute rest. Ergot is of doubtful value. It may also, in some cases, be necessary to give drugs which will increase the production of bile. Ascites is the condition for which effective treatment is eventually demanded. At its onset or to prevent re-accumulation after tapping, we may use cathartics (magnesium sulphate, compound jalap powder), diaphoretics (heat), diuretics (bitartrate of potash, diuretin, or a combination of calomel, digitalis, and squill), abdominal electricity and massage. Tapping eventually becomes necessary to overcome the abdominal distention, and it ought not to be delayed. It should be repeated as often as is necessary to relieve distress from pressure. In some cases on record the ascites has not returned after a few tappings, but this result we may not ordinarily expect, since in most cases it is to be regarded merely as a means of adding to the immediate comfort of the patient, because the fluid usually quickly returns. The quantity of fluid removed at one time may be as high as ten quarts. Pleuritic effusion will require aspiration, and that possibly repeatedly. Toward the end of life alcohol may be necessary as a stimulant, and its use should be advised without question.

2. *Surgical Treatment.* Additional proof has been produced during the past two years to the effect that the establishment of a collateral circulation by operation will greatly benefit the patient suffering from cirrhosis of the liver with ascites. The operative procedure, which is to be carried out with the strictest aseptic precautions, is described in detail in the article entitled *Liver, Diseases of: Surgical Treatment.* The reader is therefore referred to this article for further information on the subject. Although up to the present time the mortality of such surgical treatment has been somewhat heavy, it is fair to assume that when the patients are turned over to the surgeon for operation at an earlier stage, *i.e.*, before they have reached the last stages of toxæmia, the results will make a better showing.

Clarence Arthur McWilliams.

LIVER, DISEASES OF: FATTY INFILTRATION AND FATTY DEGENERATION.—There are two varieties of fatty liver: (1) fatty infiltration, (2) fatty degeneration. During life it is impossible to be absolutely certain which variety exists. However, clinical experience makes us fairly certain of our diagnosis, since we know that a history of phosphorus poisoning indicates degeneration, while the history of over-indulgence in food and drink with resulting obesity suggests very strongly infiltration. It is possible for fatty infiltration and degeneration to be present in the same case. These two conditions are distinguished by microscopical and chemical means. In most tissues fatty degeneration shows itself by the occurrence of small drops of fat which show no tendency to run together, while in infiltration large drops are usually formed. There are exceptions to this rule, however, as large-sized drops are found in fatty degeneration of the renal epithelium and in liver cells in phosphorus poisoning and in acute yellow atrophy of the liver.

It is only in tissues like those of the liver, which normally act as storehouses of fat and also frequently undergo degeneration, that much difficulty is encountered. It is often difficult to decide how much fat has been produced on the spot by disintegration of the cell albumen, and how much has been deposited from the blood.

According to Perls, chemical analysis shows that in fatty infiltration there is a much greater quantity of fat than in fatty degeneration. It proves that in fatty degeneration there is a diminution of the solid (non-fatty) matter, that is, of the albumen, while the amount of water in the liver remains normal. In fatty infiltration, on the other hand, the fat is increased mainly at the expense of the water, the watery constituents of the liver falling from 77 to 50 per cent., while the amount of non-fatty solid matter, albumen, remains about the same. William Hunter, in vol. iv. of Allbutt's system, states that in phosphorus poisoning the percentage of fat is as high as 30, water 60, and non-fatty tissue 10 per cent., while in acute yellow atrophy the fat per cent. is only 4.2, water 80.5, non-fatty substance 15.3. The normal liver, according to him, contains about 3 per cent. of fat, 76 per cent. of water, and 21 per cent. of non-fatty substance. On post-mortem examination, if the other fat-containing tissues of the body, such as the epicardium, mesentery, epiploic appendages and subcutaneous connective tissue, show an abnormal amount of fat, it is very likely that the liver will show an infiltration.

Fatty liver may be classified as *dietetic*, *cachectic*, *infectious*, and *toxic*.

Dietetic.—It is well known that the liver is normally one of the fat repositories of the body; physiologically there is a certain amount of fat in the liver cells. This does not interfere at all with the function of the liver. When this infiltration becomes excessive, it is pathological. It is difficult to draw the line between physiological and pathological fat infiltration. The latter may occur in gluttons and drunkards and those leading a sedentary life. Infants who are overfed, especially with a food containing an excess of sugar, show a fatty liver.

Cachectic.—It is rather a paradoxical fact that the various cachexias—in which there is marked emaciation—show a fatty liver. Among these cachexias the tubercu-

lous affections of lungs, bones, joints, and lymphatics are especially to be mentioned; also carcinomata of various organs, chronic suppurations, such as bone disease, old bedsores, chronic dysentery, and chronic anæmia, including leukæmia and chlorosis.

Infectious.—In the various acute infectious fevers fatty liver is found.

Toxic.—Fatty degeneration is found in poisoning by phosphorus, arsenic, mercury, camphor, chloroform, and certain vegetable fungi. Phosphorus poisoning is the best example of this variety. Since the enactment of stringent measures, enforcing the use of a more insoluble and less poisonous form of phosphorus in the manufacture of lucifer matches in the United States and England, this form of poisoning is much less common than formerly. It is still occasionally seen in Austria.

Fatty degeneration is observed in the liver as a result of venous congestion ("fatty nutmeg liver"), and it is also observed in the neighborhood of carcinomatous abscesses and in cirrhosis.

Fatty degeneration of the new-born, so-called Buhl's disease, has been described; so also has an acute fatty degeneration occurring in puerperal women.

Explanation of Infiltration and Degeneration.—The dietetic form is due to an under-combustion of the fat—which may or may not be taken into the system in excess. Indigestion, with a sluggish flow of bile (which normally carries fat from the liver), helps to explain this fact. If large quantities of alcohol are consumed, the oxygen is used in burning this up, leaving the fat to be stored up in the liver.

In the *cachectic* form, of which that occurring in pulmonary tuberculosis is the most striking example, there is deficiency of oxygen, due primarily to the lung disease, and secondarily to the fact that the functional capacity of the tissues and organs has suffered in proportion to the disease. An anæmia is also present, so that less oxygen is carried in the blood stream. The fat present in the blood of consumptives may come partly from the food, partly from the breaking up of the albumen of the organism, and in part is taken up from the disappearing adipose tissue. The combustion of fat is incomplete and it is stored up in the liver.

Toxic.—When present in the fluids of the body phosphorus produces the gravest changes in the metamorphosis of tissues: the consumption of oxygen and the excretion of carbonic acid are diminished; at the same time an increase in the decomposition of albumen occurs. The fat arises from the decomposition of albumen, and lies in the liver uncombusted, because of a lack of oxygen.

Infectious.—This fatty degeneration is attributable to the poisons of the infectious diseases, as well as to the high temperature associated with them.

In fatty nutmeg liver of heart disease, there is an under-combustion of the fat produced in the liver cells, by reason of lack of oxygen.

Morbid Anatomy.—The liver is usually enlarged; it may be twice the size of the normal organ. It may occasionally be smaller than normal, and is then usually associated with Laënnec's cirrhosis. It is pale yellow, soft, and doughy when warm, showing a permanent pitting of the surface after pressure. The edge is usually rounded and blunt. On section, a film of grease adheres to the blade. In the degeneration of phosphorus poisoning the outlines of the liver cells are indistinct, the nuclei do not stain, and a finely granular detritus or large fat drops occupy the cells.

Symptoms and Signs.—There are no characteristic symptoms of this condition. There may be a feeling of fulness and pressure in the region of the liver and the stomach. In some, especially tuberculous cases, the distress caused by the liver may be severe. The area of liver dulness is usually enlarged, and on palpation the blunt edge of the liver can be felt below the margin of the ribs. In cases of infiltration the liver is not sensitive to pressure, but in the degeneration of phosphorus poisoning it may be exquisitely tender.

Prognosis.—This depends upon the prognosis of the fundamental disease. In itself fatty liver does not tend to shorten life.

Treatment.—It is directed to the causative disease, with no especial reference to the condition of the liver. If the fundamental disease—as, for instance, obesity—is benefited, the liver will improve with the rest of the tissues of the body. *James Rae Arneill.*

LIVER, DISEASES OF: GALL STONES. See *Gall Bladder and Gall Ducts, etc.*, and *Concretions.*

LIVER, DISEASES OF: HYPERÆMIA.—(Congestion of the Liver.) A more or less persistent increase in the volume of the blood in the liver constitutes hyperæmia, and is pathological, in contradistinction to that temporary physiological increase which occurs during the period of digestion.

When the hyperæmia is due to an increased afflux of blood, it is termed a *fluxion;* when to a diminished efflux, a *congestion.* An *active* hyperæmia signifies a sudden determination of blood to the organ, or a fluxion, made manifest by definite acute symptoms; it usually subsides without structural changes in the viscus. A repetition of such an hyperæmia, and especially with an increased volume of blood in the hepatic artery, leads to the gradual development of interstitial hepatitis or cirrhosis. A *passive* hyperæmia, diminished efflux, is developed slowly, with few accompanying symptoms until after structural, changes which usually occur, have taken place.

An *active* hyperæmia is essentially acute; a passive, chronic. Some passive hyperæmias, however, occur in a short space of time, as in the form that accompanies a large pleural effusion.

Mechanical hyperæmia, active or passive, is caused by an obstruction to the outlet of blood, and this obstruction may be seated in the vena cava, the heart, or the pulmonary circulation.

It is, however, wellnigh impossible to separate the various forms of hyperæmia by hard-and-fast lines, and clinically it suffices to consider hyperæmias as either active or passive—which terms are practically synonymous with acute and chronic congestion of the organ. The difficulty of accurate subdivision arises from the fact that the various forms blend. Three sets of vessels are involved in the occurrence of congestion. The congestion due to over-repletion in the hepatic veins differs in form and behavior from that due to portal fulness. The two forms are readily distinguished by a consideration of the primary causal factors. To distinguish the hyperæmia which is due to an excess in the portal system of veins, from that which is dependent upon a fulness of the hepatic artery, is clinically impossible and scarcely practicable.

Etiology.—Active hyperæmia, acute congestion. The ingestion of *stimulating food* and *drink* causes active hyperæmia. When alcohol, fermented liquors, spices, and rich foods are taken frequently or in excess, especially by delicate persons who lead a sedentary life, the normal congestion associated with digestion becomes excessive and more or less permanent. Musgrove (*Medical Record,* 1902) considers the over-indulgence in highly seasoned articles of diet as seen in the East, and the consequent hyperæmia of the liver, to be directly contributory to the frequency of hepatic abscess. Residents in hot climates, with or without such indulgence, are particularly prone to attacks of hepatic congestion; hence *high temperature* has been considered a causal factor. Sudden checking of the *perspiration,* a severe and sudden, or a prolonged, *chill* or repetition of chills, is followed quite frequently by active hyperæmia. Persons living in a *malarious* region are liable to attacks of hepatic, as well as of splenic, congestion. During the *seasons* when malaria is rife, or when the changes in temperature are sudden and extreme, the disease is most liable to occur. Congestion of the liver is found, too, in many *infectious diseases,* as relapsing fever, yellow fever, epidemic cerebrospinal meningitis, and scarlet and typhus fevers.

After traumatism, a determination of blood to the injured area of hepatic tissue is always observed. It is said, also, that hyperæmia of the liver occurs in scurvy.

The suppression of customary discharges, especially of blood, causes fluxion to the liver. Cessation of the menses at the menopause, or by cold or nervous influence, and arrest of the hemorrhages of uterine disease from various causes, are not uncommonly followed by attacks of hepatic congestion. So, also, congestion of this organ not infrequently follows the stanching of hemorrhoidal bleeding.

It is said that habitual constipation induces passive congestion of the liver. It is difficult to prove, yet it can readily be surmised as possible that paralysis of the sympathetic nerve causes torpor of the hepatic circulation. It is true that we see in some diseases—as tuberculous peritonitis, in which the contents of the abdomen are jumbled into a mass and the sympathetic ganglia are degenerated—a hyperæmia of the liver; a condition, however, which could be explained by the assumption that the portal capillaries are obstructed. As Thierfelder suggests, the congestion associated with diabetes mellitus may be due to paresis of the abdominal sympathetic. The sluggishness of the circulation, which occurs in persons who exercise sparingly, is markedly seen in the stasis that occurs in the liver.

Active or acute congestion of the liver, therefore, is liable to occur in persons of sedentary habits, without muscular vigor, who are high livers and reside in hot climates. It should not be forgotten, however, that its occurrence in temperate climates, though of comparative infrequency, is yet not very rare. A chill, or sudden checking of perspiration, is a frequent exciting cause. Malaria is most commonly observed, of all diseases, to excite an attack. Hepatic congestion occurs most frequently in the autumn, and usually affects individuals of middle life.

The most important and frequent causes of hyperæmia of the liver, whether in temperate or in tropical climates, are mechanical. The forms of heart disease which cause backing of the blood into the venous system—such, for example, as cardiac dilatation and mitral and tricuspid valvular disease—are attended by hepatic congestion. In emphysema, interstitial pneumonia, and atelectasis, the venous flow is obstructed. The form of congestion is, under these circumstances, passive. Tumors of the mediastinum, aneurisms, thrombosis and tumors of the inferior vena cava, effusions in the pleura,[1] pressing upon or bending the vena cava, also cause hepatic congestion.

Symptomatology.—It is manifest that the symptoms of hyperæmia of the liver differ according to the cause. Moreover, they are intermingled with the symptoms that belong to the respective causal factors. In mechanical hyperæmia, for instance, the symptoms of obstructive heart or lung disease are present, along with those of hepatic congestion. In active hyperæmia the hepatic symptoms are less complicated, and serve as a type of the acute form.

After a chill, excesses in diet, or exposure to high temperature, complaints of pain in the liver, and of weight and fulness in the right hypochondrium, are made. The pain may extend to the right shoulder, is constant and associated with tenderness of the liver, and is excited by palpation along the margin of the ribs. Febrile reaction, not marked, attends the attack for two or three days, while general *malaise* is marked. At the same time a bad taste in the mouth, a tongue heavily coated with a yellowish material, nausea, thirst, anorexia, epigastric fulness, flatulency, and often vomiting, are present. The bowels, at first torpid, are relieved by diarrhœa. A gastro-intestinal catarrh usually accompanies the hepatic congestion, in which case vomiting and diarrhœa are more frequent. The ejecta from the stomach are composed of the food, an acid, glairy mucus, and bile-stained watery fluid. The stools are clay-colored and pasty, or watery, acid, and greenish, or dark-colored. Often there is some dyspnœa, and the so-called liver cough is present. Headache, usually frontal, accompanies the attack, and is associated with vertigo.

On physical examination the liver is found to be enlarged, extending two or three inches below the margin of the ribs. Its edge is rounded, elastic, and smooth on palpation.

In a day or two the conjunctivæ become yellowish, and even a light degree of general jaundice supervenes. The jaundice is due to associated catarrh of the gall ducts, or to pressure on them by the engorged vessels. Languor and debility continue for some time, while melancholy and hypochondriasis commonly occur. The countenance, at first flushed, or if the pain is severe, anxious and pinched, grows sallow and worn.

The urine is scanty and high-colored. It contains an excess of urates, some bile pigment if there is jaundice, and often small amounts of albumin and sugar (functional albuminuria and glycosuria). The presence of these ingredients may be intermittent, and may vary with the diet.

If the hyperæmia persists, the overloaded state of the portal vessels results in sluggish absorption of the products of digestion and over-repletion of the vessels of the gastro-intestinal mucous membrane. A true catarrh of the tract arises, and is all the more aggravated and persistent on account of the vascular stasis. Its symptoms replace largely those of congestion. In passive and mechanical hyperæmia, this catarrh is most marked. In these forms the liver is large, more firm, but less tender on palpation. Its size, in hyperæmia due to obstruction, is variable. Depletion by a purgative, or removal or relief of the cause (cardiac dilatation, etc.), would reduce it, and a recurrence of the cause would again be followed by enlargement. This temporary change characterizes mechanical hyperæmia. An enlarged, congested liver may be temporarily increased in size by sudden obstruction in some other area of the blood circuit. A pneumonia or a pleural effusion may thus aggravate the hepatic engorgement, and in turn be aggravated by the old liver disease.

The stasis in the hepatic circulation may be so extreme as to cause over-fulness in the portal vessels and secondary enlargement of the organs in that area. An ascites, out of proportion to the general anasarca usually present, will arise, the spleen becomes enlarged, and the hemorrhoidal vessels are dilated. The secondary phenomena are more probable if the changes incident to overgrowth of the cellular tissue of the liver ensue. In this class of cases the liver is diminished in size, and, if palpable, is very firm and hard.

Course, Duration, and Prognosis.—The course and duration are largely determined by the cause. An active congestion of the liver will subside usually in from two to three weeks. The subjective symptoms are often removed, while enlargement of the organ may continue for some time. Congestions of the liver which originate on the portal side of the hepatic circulation are more amenable to treatment, and last a shorter time, than the congestions on the hepatic side. The latter are due to chronic heart and lung disease, and in their varying course, now better, now worse, depend upon the primary causal agency. The prognosis, likewise, depends on the cause. When the liver becomes enlarged from congestion, and subsequently undergoes marked atrophy, the prognosis of the hepatic trouble is serious, and it in turn renders more grave, day by day, the primary disease. Care must be exercised not to mistake the initial congestion of true cirrhosis for simple hyperæmia. An active congestion of a liver, in which the anatomical structures are abnormal from previous disease, is serious and may fatally terminate a slow cirrhosis or a fatty liver.

Diagnosis.—The diagnosis is usually easy, but the condition cannot be clearly recognized unless the causal influences previously mentioned be evident. In addition to the cause, the shape and size of the liver, the gastro-intestinal catarrh, the condition of the urine, and the signs of secondary portal obstruction, must also be considered.

Morbid Anatomy and Pathology.—Before advanced secondary changes have taken place the liver is uniformly enlarged. The enlargement is most marked in the thickness of the organ. The surface is smooth, the capsule transparent, the edges are thick and rounded. On section, dark blood oozes freely from the vessels. The tissue is soft and darker in color than normal. The vessels are dilated; the enlargement of the hepatic vein in the acini is especially distinct in passive congestion, though a similar increase in size of the portal vessels occurs when the engorgement is limited to that side of the circulation. Throughout the substance of the organ numerous hemorrhages are seen. On microscopical examination, the vessels are seen to be dilated and their walls thickened by increased cell proliferation and the migration of leucocytes. Atrophy from compression of the hepatic cells is marked. A catarrh of the minute ducts is often present.

In the more advanced stages the atrophy of the cells is more marked, pigmentation and fatty degeneration of the cells in the portal zone are present, to a great degree, and the cell proliferation and the infiltration of leucocytes are not only seen in and about the vessel walls, but also between the hepatic cells of the individual acini. New-formed bile ducts are frequently to be seen in the new-formed connective tissue. This is due to an overgrowth of connective tissue, or to greater distinctness of the cells on account of destruction of the hepatic cells. A liver that presents such histological changes is called the *nutmeg liver*. It is normal in size or lessened, firm on section. The capsule is opaque, and the surface and interior are granular, the latter gorged with blood. The acini are distinct, the central vein much dilated and dark in color. The periphery of the lobule is yellow, the centre dark red. The term "nutmeg" is applied to the marbled appearance.

In more advanced stages the overgrowth of connective tissue is extreme, and leads to great atrophy and pigmentation of the gland elements. Crystals of hæmatin are observed free in the tissues. The liver is small, very firm, dark red. Such is the liver of *cyanotic atrophy*. The same macroscopical appearances are seen in *cyanotic induration*, but the increase of the connective tissue is greater, the cells are more degenerated, and the vessels are more engorged. These advanced changes are located in the region of the hepatic vein, while the interstitial overgrowth in cirrhosis begins in the portal veins.

Treatment.—The first indication to be met is the removal or amelioration of the cause. The methods to be pursued readily suggest themselves to the physician if he possesses a knowledge of the cause and mechanism of the congestion. Thus, the diet must be well selected, and bland, non-stimulating articles are to be given. Rich foods, pastries, condiments, sugars, and starches are to be avoided. Milk, eggs, beef-broth and beef-tea, lean meat, succulent vegetables, and acid drinks are required. Systematic exercise is essential, especially in sedentary subjects. Daily walks, horseback riding, sailing, are all good. Horseback riding is the best. A change of air, especially a residence by the sea, is often beneficial. Bathing, sponging, and douching is of much service.

The acute manifestations are best treated by local depletion, with morphine given internally to relieve the pain. Wet-cups over the liver, and leeches in the same area or around the anus, are to be used. If the pain is not so severe, mustard plasters are stimulating enough, and large poultices may be employed subsequently. Some few authorities assert that the engorgement which ensues is relieved by puncturing the liver through the abdominal walls with a long needle. Though long ago advocated, this practice has never been in vogue, but recently it has attracted attention by the advocacy of Dr. George Hurley.

To assist further in the depletion of the hepatic circulation, purgatives are indicated. The salines are of great value. Phosphate of soda, Rochelle salts, citrate of magnesia, and other salines may be used, preference being

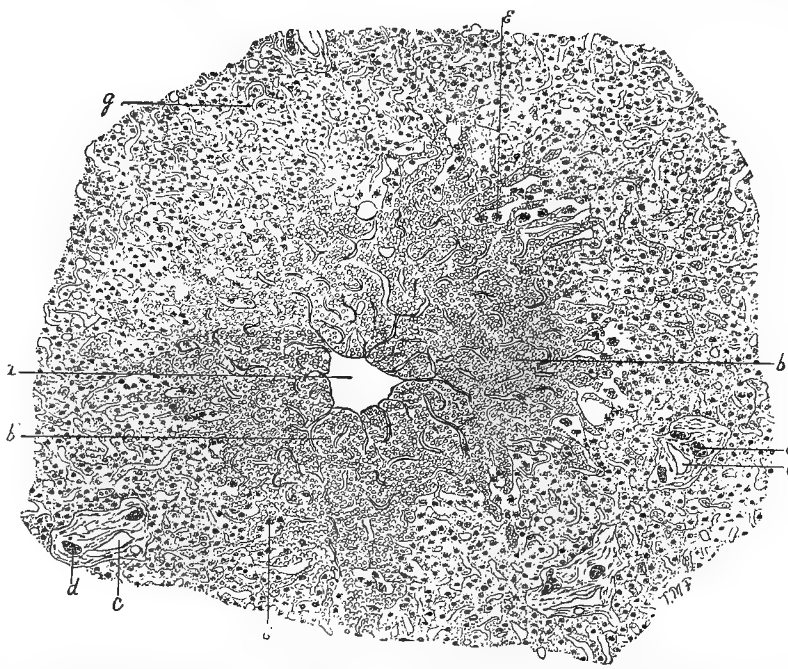

Fig. 3226.—Chronic Congestion of the Liver. (× 300 and reduced.) Complete atrophy of the liver cells at the centre of a lobule. *a*, Dilated vena centralis; *b*, dilated capillaries filled with blood; *c*, portal vein surrounded by connective tissue; *d*, gall ducts; *e*, atrophied liver cells; *g*, nearly normal liver tissue. (From Delafield and Prudden's "Handbook of Pathological Anatomy and Histology.")

given to those first named. If there is much nausea or vomiting it may be relieved by small doses, from one-sixteenth to half a grain, of calomel frequently repeated, taken dry on the tongue. Some practitioners use large doses of the drug at once, and see evidences of liver congestion and torpor in every disease. The resinous cathartics are used by many, podophyllin being the favorite.

If the congestion of the liver be due to cold or checking of the perspiration, remedies to equalize the circulation must be administered. Saline diaphoretics or Dover's powder, a warm bath or a foot-bath, aconite or veratrum to quiet the circulation, and bromides to allay nervous excitement, are indicated. If there is much pain, small doses of Dover's powder are of great service, the ipecac which this preparation contains being of special utility. In malarious districts, large doses of quinine are used. In fact, quinine and calomel form the sheet-anchor combination for many practitioners. High temperature must be combated, and the usual remedies to relieve the cardiac and pulmonary affections that are the primary source of the congestion should be administered.

There are two drugs that have acquired a great reputation in the treatment of congestion of the liver, viz., muriate of ammonia and ipecacuanha. Their use origi-

nated in the East. The muriate of ammonia is given in doses of from gr. x. to gr. xxx. every four or six hours, and it speedily gives relief. Ipecacuanha is given in the same way as in the treatment of dysentery. The patient must be at rest, and the dose of ipecac should be preceded by a small dose of laudanum and by the application of a mustard plaster to the epigastrium. In this manner vomiting is often prevented. From thirty to sixty grains of the drug, every four or six hours, are given.

Alkalies are of great service in congestion of the liver. They must be administered well diluted, and on an empty stomach. It is advantageous to use the alkaline solution hot, and to sip it slowly. The natural mineral waters may be used. Those of Vichy, of Ems, and of Carlsbad, or the Hathorn and Congress waters of this country, are indicated.

The so-called grape-cure, and the whey-cure, were at one time quite in vogue in Germany, and both are, no doubt, of great value.

Of course, the patients who can afford it will be much benefited by a residence at the springs, taking a course of the waters and following the prescribed diet.

Some cases of chronic congestion of the liver refuse to yield to the system of treatment just indicated. In such, external applications over the surface of the liver are necessary. The compound ointment of iodine or the biniodide of mercury is of service. Care must be exercised to secure by the mercury only a slight ptyalism. Of more advantage than either is the nitric-acid pack or bath. An ounce of the acid is added to two gallons of water and cloths saturated with the solution are applied over the liver. If a mixture in this proportion be found too strong it must be further diluted with water. It causes extreme itching and burning or pricking of the skin. The acid bath is strongly recommended. Sir Ronald Martin directs that the bath should be composed of two ounces of strong hydrochloric acid and one of strong nitric in two gallons of water, at a temperature of 98° F. Both feet are to be placed in the bath; the abdomen, the hepatic region, the axilla, and the inner sides of the legs and thighs are to be sponged alternately, or the abdomen may be swathed in flannel saturated with the fluid. The process is to be repeated night and morning for half an hour. The fluid should be kept in wooden or earthen vessels, and the sponges and towels kept in cold water. The quantity of fluid may last for five or six days by adding each day a pint of water which contains the proportionate amount of acid. It should be well heated to raise the temperature of the entire bulk of fluid.

After a course of alkalies, or the use of the means suggested above, the patient is enfeebled and the digestion weak. Tonics are therefore now indicated. The mineral acids, quinine, and nux vomica are the best. With or without gastric disturbance, the chalybeate alkaline waters are of great value. Especially after a course at the "springs," an after-course should be taken at other springs, where a stimulating outdoor life and tonic waters would add to the vigor of the patient. In this period of convalescence the diet must be carefully selected, some mild wines employed, and particular attention directed to the regulation of the bowels by gentle saline laxatives.

ADDENDUM.

The writer has collected some interesting facts concerning hepatic disease in a study of all the cases of liver disease presented to the Pathological Society of Philadelphia, from 1857 to 1881, inclusive. The condition of the liver was recorded 430 times -184 times normal and 246 times diseased. In 10 instances the liver was congested, in cases in which death occurred from accidental causes. The subjoined table indicates the proportionate frequency of occurrence of congestion of the liver, simple and nutmeg, in 246 cases of liver disease. It is of interest to note that in 36 cases of cardiac disease the liver was healthy 5 times, the seat of *nutmeg congestion* 9, and of simple *congestion*, 4 times. Nine times it was fatty; 8 times cirrhotic; 1 the seat of red atrophy (due to congestion). Of 13 instances of nutmeg congestion, 9 attended cardiac disease; 1 chronic pleurisy; 2 carcinoma (heart weak); and 1 chronic diarrhœa. The liver was enlarged 8 times in 13. The spleen was enlarged 6 times; healthy, 2; cirrhotic, 1; not mentioned, 4 times in the 13 cases. The kidneys were congested or cirrhotic in 10 of the 13 cases. Eleven of the cases were males; 6 of them were over forty, 5 between twenty and forty, and 2 under twenty. In no instance were symptoms referable to the liver recorded.

TABLE OF RELATIVE FREQUENCY OF ALTERATIONS OF HEPATIC STRUCTURE (TOTAL NUMBER OF CASES TWO HUNDRED AND FORTY-SIX.)

Variety.	No. of cases.
Fatty	80
Carcinoma	41
Cirrhotic	38
Congestion	24
Congestion, nutmeg	13
Abscess	13
Tuberculosis	9
Syphilitic gumma	5
Hydatid disease	4
Rupture of liver	3
Hemorrhage into liver	2
Pigment liver	3
Amyloid liver	2
"Diseased" liver	3
Leukæmic, "atrophied," red atrophy, chronic hepatitis, cavernous angioma, myeloid tumor, one each	6

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[1] Bartels: Left Pleural Effusions.

LIVER, DISEASES OF: INJURIES. See *Abdomen. (Surgical).*

LIVER, DISEASES OF: NEW GROWTHS.—Of the tumors of the liver carcinoma is the most important. Fifty per cent. of the cases are said to occur between the fortieth and sixtieth years. It is found occasionally in children, and women seem to be attacked less frequently than men. An association between carcinoma of the bile passages and gall stones has been noted. Whether there is an etiological relation between the two has not been determined.

MORBID ANATOMY.—There may develop in the liver *adenomata* whose structure differs in certain respects from that of the normal organ. They are usually multiple, and about as large as a pea. They are not always sharply defined and ordinarily project from the cut surface. They consist of liver cells which commonly are arranged in double rows, and, in those cases in which the adenomata are found in otherwise normal livers, are connected with the liver cells in the neighborhood. They thus resemble less the true tumors than localized circumscribed areas of *hypertrophy* or *hyperplasia.*[1] They do not possess the independence that is involved in tumors.

They perhaps develop as a result of fœtal processes. They may be surrounded by a connective-tissue capsule. The vessels of the nodule are connected with the surrounding vessels. If there is no fibrous capsule, the capillaries as well as the rows of cells are continuous with those of the normal tissue. According to Orth,[2] Sabourin maintains that the nodules correspond to secretory lobules, having as a centre an interlobular portal vein and bile duct, and extending to the central veins of the surrounding acini; and if they are larger, they nevertheless correspond to the territory of distribution of a portal canal. He therefore seeks the etiology in changes in these portal or biliary vessels.

These hypertrophic adenomata must be distinguished from the true *tubular adenomata.* These occur as multiple nodules of various sizes that may bring about considerable enlargement of the liver. They may be encapsulated and consist of cylinders arranged in the form of gland tubules, which frequently have a tortuous course and possess distinct lumina that may contain fluid. The origin has been ascribed both to the liver cells and to the bile ducts. They may or may not be associated with cirrhosis. Metaplasia may result in the production of typical carcinoma.

In cirrhosis of the liver when large and especially spherical, tumor-like granules project from the surface, the possibility of a secondary enlargement, as a result of hypertrophy, or even the formation of adenomata must be considered.

The hypertrophic nodules contain enlarged liver cells often in the form of giant cells. They may be transformed partially or entirely into small-cell tubular adenomata. Proliferating rapidly they may push aside the

surrounding tissue or they may infiltrate it. In spite of the cirrhosis considerable enlargement of the organ may be brought about by these grayish-red or grayish-brown nodules. Metastases may result from the adenomata as such or they may first be transformed into true carcinomata. In these cases of *cancer with cirrhosis* the cirrhosis is apparently the primary process. On section of the liver one usually sees apparently multiple tumors, but, according to Ribbert,[6] more careful examination shows that he is dealing with cross sections of tumor cords. These new growths penetrate first into the capillaries, then into the larger vessels, the portal and hepatic veins. The reason for this will be more apparent if one recalls the close relation between the liver cells and the vascular system. In the portal veins the growth may reach the main trunk and extend from there peripherally into other branches. When these are cut transversely they appear like isolated tumor nodules. Metastases in the lungs are very common. Through the lymph vessels large metastases may be formed in the portal lymph nodes.

These tumors possess a certain similarity to the structure of the normal liver. The cells in the neighborhood of the liver cells are arranged in the form of anastomosing cords usually consisting of many layers. In the interstices are the blood-vessels with practically no connective tissue. Bile may be formed. Bile pigment appears in the epithelial cells or the secretion collects in small canals which resemble bile capillaries, but with a different arrangement, and which pass longitudinally among the cords. The same process may occur in the metastases.

Primary carcinomata are rare. They apparently may arise from the liver cells or from the smaller bile ducts. Some are periportal in distribution, the nodules following the periportal connective tissue and being smaller in direct proportion to their distance from the hilum. According to Ziegler,[8] these originate from the bile ducts. *Cystic adenomata* arising from the bile ducts may be in the form of single large cysts or large multilocular cysts. These are rare. Perhaps a portion of the congenital cysts belong in this class. The primary *nodular carcinomata* are often very large and most frequently occur in the right lobe. They may be single or they may appear in company with smaller, apparently secondary tumors.

Secondary carcinomata are much more frequent. Those that originate by direct extension from neighboring organs may have an arrangement similar to that of the nodular primary carcinomata. They may be much larger than the primary tumor and may be thus mistaken for primary tumors. One should therefore search carefully the neighboring organs, especially the gall bladder and the stomach, for a primary tumor. In the case of metastatic carcinomata a considerable number of isolated tumors of fairly uniform size is usually present. They originate from primary tumors in various organs. The primary tumors are most often in the stomach or some other organ in which the branches of the portal vein are distributed; but metastases in the liver may occur apparently in the case of a carcinoma in any part of the body. Microscopically the secondary tumors tend to present the same cellular and general structure as the primary. The structure may thus give a clew to the origin of the tumor.

All carcinomata of the liver tend to undergo central fatty degeneration and atrophy. In the case of the superficial nodules this is expressed by the presence of central umbilication, corresponding to the central atrophy resulting from the resorption of the fatty detritus. By complete fatty degeneration and softening of the central portions there may be formed spaces filled with more or less liquid material.

In the case of some secondary carcinomata, especially those originating from the stomach, one may demonstrate that they have developed apparently from embolic carcinomatous thrombi in the branches of the portal vein. In this way the network of the interlobular branches of the portal vein and the capillaries of the lobules in a considerable territory may be filled and distended with tumor masses. As a result the liver cells become compressed and distorted and finally undergo atrophy associated with an accumulation of brown pigment. At the periphery of the nodular secondary carcinomata the liver cells are often flattened and assume a concentric arrangement in a number of layers.

From the smaller vessels the growth occasionally extends into the hepatic veins, which then become filled with carcinomatous thrombi, that may extend into the vena cava. According to Orth,[2] it is this obstruction of the vessels, apparently, which leads to the cyanotic atrophy so common in the liver tissue between the tumor nodules.

According to Orth[2] the injection experiments of Frerichs have shown that the vessels of the carcinomata may be injected from the hepatic artery, but not from the portal vein. The branches of the hepatic artery become considerably enlarged.

Primary sarcomata and *fibromata* are very rare. *Secondary sarcoma* is more frequent. The metastatic secondary sarcomata, including the melanosarcomata, are identical with those which occur in other regions.

"The most important form is the melanosarcoma, which develops in the liver secondarily to sarcoma of the eye or of the skin. Very rarely melanosarcoma develops primarily in the liver. . . . In this form the liver is greatly enlarged, is either uniformly infiltrated . . . which gives the cut surface the appearance of dark granite, or there are large nodular masses of a deep black or marbled color."[5] The intravascular growth and embolic origin of secondary melanosarcoma are often very apparent. Extensive softening with cyst formation may occur. "There are usually extensive metastases, and in some instances every organ of the body is involved. Nodules of melanosarcoma of the skin may give a clew to the diagnosis."[5]

Rare forms of tumors have been described as myxosarcomata, gliosarcomata, leiomyomata, rhabdomyomata, etc.

Cavernous hæmangiomata are met with more often than the primary sarcomata. Varying greatly in size they may be just visible to the naked eye or as large as an apple. They are characterized by their dark red, sponge-like structure, the spaces being filled with blood. They may be multiple. The framework consists of connective tissue, sometimes containing smooth muscle fibres, or of liver cells. The larger forms are sometimes encapsulated and even pedunculated. Thrombosis followed by organization may lead to fibrous metamorphosis of the structure. Small *cysts* lined by simple or ciliated epithelium are to be regarded as congenital retention cysts resulting from adenomatous proliferation in the bile ducts. Occasionally they occur in large numbers, conspicuously in connection with cystic degeneration of the kidneys. Cysts originating after birth, likewise as a result of partial distention of bile ducts, are characterized, according to Orth,[3] by their firmer fibrous wall, and their contents, which, at least in the earlier stages, consist of bile-like material and later of cholesterin and less often of concretions. Both forms almost always occur immediately beneath the capsule.

Nodules of *adrenal tissue* in the liver have been described.

We may regard *lymphatic leukæmia* and *pseudoleukæmia* as closely analogous to tumor formation. The collections of lymphoid cells filling and dilating the capillaries of the liver and the masses of lymphoid tissue, which may cause considerable enlargement of the organ, may then be regarded as metastatic tumors.

SYMPTOMS.—"It is often impossible to differentiate primary and secondary cancer of the liver unless the primary seat of the disease is evident, as in the case of scirrhus of the breast, or cancer of the rectum, or of a tumor in the stomach, which can be felt. As a rule, cancer of the liver is associated with progressive enlargement."[5] "With the exception of the fibromyomata of the uterus cancer of the liver may constitute the largest tumor met with in the abdomen."[4]

"But there are cases of primary nodular cancer, and in the cancer with cirrhosis the organ may not be en-

larged. Gastric disturbance, loss of appetite, nausea, and vomiting are frequent. Progressive loss of flesh and strength may be the first symptoms. Pain or a sensation of uneasiness in the right hypochondriac region may be present, but enormous enlargement of the liver may occur without the slightest pain. Jaundice, which is present in at least one-half of the cases, is usually of moderate extent, unless the common duct is occluded. Ascites is rare, except in the form of cancer with cirrhosis, in which the clinical picture is that of the atrophic form. Pressure by nodules on the portal vein or extension of the cancer to the peritoneum may also induce ascites.

"Inspection shows the abdomen to be distended, particularly in the upper zone. In late stages of the disease, when emaciation is marked, the cancerous nodules can be plainly seen beneath the skin, and in rare instances even the umbilications. The superficial veins are enlarged. On palpation the liver is felt, a hand's breadth or more below the costal margin, descending with each inspiration. The surface is usually irregular, and may present large masses or smaller nodular bodies, either rounded or with central depressions. In instances of diffuse infiltration the liver may be greatly enlarged and present a perfectly smooth surface. The growth is progressive, and the edge of the liver may ultimately extend below the level of the navel. Although generally uniform and producing enlargement of the whole organ, occasionally, when the tumor develops from the left lobe, it may form a solid mass, which occupies the epigastric region. By percussion the outline can be accurately limited and the progressive growth of the tumor estimated. The spleen is rarely enlarged. Pyrexia is present in many cases, usually a continuous fever, ranging from 100° to 102°; it may be intermittent, with rigors. This may be associated with the cancer alone, or . . with suppuration. Œdema of the feet, from anæmia, usually supervenes. Cancer of the liver kills in from three to fifteen months. One patient lived for more than two years." [5]

Diagnosis.—"The diagnosis is easy when the liver is greatly enlarged and the surface nodular. The smoother forms of diffuse carcinoma may at first be mistaken for fatty or amyloid liver, but the presence of jaundice, the rapid enlargement, and the more marked cachexia will usually suffice to differentiate it. Perhaps the most puzzling conditions occur in the rare cases of enlarged amyloid liver with irregular gummata. The large echinococcus liver may present a striking similarity to carcinoma, but the projecting nodules are usually softer, the disease lasts much longer, and the cachexia is not marked." [5] "The tumor masses may be so prominent, soft, and fluctuating that the condition of abscess of the liver may be suspected." [4]

"Hypertrophic cirrhosis may at first be mistaken for carcinoma, as the jaundice is usually deep and the liver very large; but the absence of a marked cachexia and wasting, and the painless, smooth character of the enlargement are points against cancer. When in doubt in these cases, aspiration may be safely performed, and a positive indication may be gained from the materials so obtained. In large, rapidly growing secondary cancers the superficial rounded masses may almost fluctuate and these soft tumor-like projections may contain blood. The form of cancer with cirrhosis can scarcely be separated from atrophic cirrhosis itself. Perhaps the wasting is more extreme and more rapid, but the jaundice and the ascites are identical. Melanosarcoma causes great enlargement of the organ. There are frequently symptoms of involvement of other viscera, as the lungs, kidneys, or spleen. Secondary tumors may develop on the skin. A very important symptom, not present in all cases, is melanuria, the passage of a very dark-colored urine, which may, however, when first voided, be quite normal in color. The existence of a melanosarcoma of the eye, or the history of blindness in one eye, with subsequent extirpation, may indicate at once the true nature of the hepatic enlargement. The secondary tumors may develop some time after the extirpation of the eye, as in the case under the care of J. C. Wilson, at the Philadelphia Hospital, or, as in a case under Tyson at the same institution, the patient may have a sarcoma of the choroid which had never caused any symptoms." [5]

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LIVER, DISEASES OF: PERIHEPATITIS.—Perihepatitis, or inflammation of the capsule of the liver, may be acute or chronic. It is usually a secondary affection. The instances of primary acute perihepatitis are rare, and are due to direct injury, or are associated with acute peritonitis or inflammations adjoining. A chronic perihepatitis is said to arise from the long-continued pressure produced by tight lacing, or by wearing a strap about the waist to support the trousers. An hypertrophied heart may cause a similar inflammation on the blunt margin of the left lobe (Thierfelder). Secondary perihepatitis arises by extension of inflammatory processes seated in the neighboring structures. Affections of the diaphragmatic pleura, and of the stomach, duodenum, or pancreas, causing local peritonitis, are attended by perihepatitis. It may be caused by disease of the ribs lying over the organ. All forms of general peritonitis involve the portion of the membrane that covers the liver. The larger number of cases arise by contiguity from some disease of the liver. It is seen in cirrhosis, cancer, abscess, and hydatid cysts, lying near the surface. The presence of gall stones in the gall bladder, cholecystitis, and the occurrence of attacks of hepatic colic, are very frequently attended by local peritonitis.

The investing capsule in perihepatitis is opaque and thickened from the formation of new connective tissue. The liver is intimately attached to adjacent structures. It is rendered more globular or rotund in those cases in which the capsule is the seat of chronic inflammation, and is tightly stretched over it. The adjacent hepatic tissue is not generally altered. Roller and Frerichs state that true cirrhosis may proceed from the chronic capsular inflammation. Sometimes processes of connective tissue are sent out into the parenchyma. Inflammation about the portal fissure leads to subsequent stricture of the hepatic ducts by contraction of the inflammatory new growth. The spleen is rarely enlarged, possibly in many cases owing to an existent perisplenitis. In many cases the disease is part of a chronic proliferative peritonitis; adhesive pleuritis and pericarditis may also be present. Under the title of "pericarditic pseudo-cirrhosis (hepatic)," Pick describes some of these cases; the tendency is, however, not to accept the perihepatitis and accompanying cirrhosis (sometimes seen) as due to or consequent upon the obliterative pericarditis, but as part of a general proliferative process.

The *symptoms* of acute perihepatitis are often severe. Sudden, sharp, lancinating pain in the region of the liver, increased by movement, by respiration, or by pressure, is experienced. Some dyspnœa is provoked by the interference with the breathing. Marked fever attends these phenomena during the first three or four days. The presence of a friction murmur may be detected by auscultation in some rare instances. An acute pleurisy of the right side is very strongly simulated by perihepatitis. Chronic perihepatitis is attended by dull pain, and by friction sounds and fremitus. It may, however, proceed without symptoms for years. After adhesions have formed the liver may not move upon deep inspiration. In some cases, in which owing to extreme contraction of the new-formed tissue the portal

and lymphatic circulation is interfered with, ascites develops, which with a markedly diminished liver area gives a more or less suggestive picture of cirrhosis. The course of these cases is very chronic up to fifteen years, and paracentesis abdominis may be performed an enormous number of times (three hundred and one in one instance).

The *treatment* is simple. Rest must be enjoined. Warm compresses or poultices to the right hypochondrium may give relief. A flying blister is almost always beneficial. In chronic perihepatitis more prolonged counter-irritation, as by iodine, is required. Morphine, by the mouth or subcutaneously, is necessary in the acute cases. Other opiates may be used. Otherwise the treatment must be directed to the cause.

It is not to be forgotten that the presence of old adhesions between the liver and the diaphragm is often a wise provision. The vessels that develop in the tissue are utilized for setting up a collateral circulation, when the normal hepatic vessels are occluded or compressed. This remark has no reference to the treatment.

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LIVER, DISEASES OF: SURGICAL TREATMENT.—Anatomy.—The lower limits of the pleura are of considerable importance in the operative treatment of diseases of the liver. This is particularly the case when it is necessary to divide or resect one or more of the ribs or costal cartilages. In the right papillary line the limit of the pleura corresponds to the lower border of the sixth costal cartilage. In the axillary line it is at the lower border of the ninth. Posteriorly the lower limit of the pleura passes outward horizontally from the lower border of the twelfth dorsal vertebra, so that the cartilage and the lower half of the twelfth rib are outside of it. By excision of one or more of those cartilages which lie outside of the pleural limit access to the liver and bile passages can be materially facilitated.

The fundus of the gall bladder is usually situated at the lower edge of the ninth costal cartilage at the outer edge of the right rectus muscle. When distended it may be felt through the abdominal wall. Between the ninth and tenth ribs the lower border of the liver passes obliquely across the epigastrium to the anterior end of the eighth rib on the left side.

Preparation for Operations on the Liver.—The preliminary measures used in abdominal operations are employed with equal care in operations on the liver and bile passages. Special stress should be laid upon thorough evacuation of the stomach and intestines. The presence of gas in the intestines may be a serious hindrance to satisfactory exposure of the field of operation and to successful manipulations on the deep structures concerned. The surgeon must expect to meet with difficulties during the course of the operation, particularly in the case of the gall passages. What appeared to be a simple case may prove a complicated one requiring deep dissection, opening and suture of one of the ducts, or even an anastomosis between the gall bladder and intestine. The surgeon must therefore be prepared for any of these possibilities, and an operation should be undertaken only under the most favorable conditions as regards room, light, instruments, assistance, etc. In cases of marked cholæmia Robson gives thirty-grain doses of calcium chloride previous to the operation for the purpose of diminishing the tendency to hemorrhage.

The position given the patient on the operating table is in most cases the usual dorsal one. When it is essential to have the best possible access to the field of operation the reversed Trendelenburg position may be employed. The patient is hung by straps under the arms on an inclined plane of about 45°. A sand-bag is placed under the middle of the back so that the patient is bent over it. The use of a sand-bag in this way is in itself a valuable means of increasing the space for working in the upper part of the abdomen.

Abdominal Incision.—The abdominal incision used depends somewhat upon the nature of the case, but there are individual preferences for one or the other form. The oblique incision below and parallel to the free border of the ribs is a favorite one and gives a good exposure. It may be lengthened in either direction. In the case of gall-bladder operations its centre corresponds to the tenth costal cartilage. A vertical incision downward from the tip of the tenth costal cartilage along the outer border of the right rectus also gives a good exposure. Some surgeons divide the rectus muscle in the course of its fibres. When a great deal of room is necessary an angular incision may be employed. A vertical incision in the linea alba is followed by a horizontal one below the umbilicus (Czerny). Excision of one or more of the costal cartilages is occasionally done for the sake of gaining space. In case of tumors or enlargements of the liver or bile passages the incision is made over the prominence of the swelling. The nerve supply of the rectus should, when possible, be preserved.

General Technique.—One or two important principles of technique may be briefly referred to. Sterile gauze pads afford the best means of protecting the intestines from infection and of walling off the field of operation. By means of them infectious foci can be attacked at one sitting without fear of soiling the general peritoneal cavity. Furthermore, they prevent the intestine from encroaching upon the part that is being operated upon, and this is an important consideration when working on the bile ducts.

Drainage is employed in some form in nearly all operations on the liver or bile passages. Hydatid cysts, abscesses, and distended gall bladders are best drained by means of rubber tubing. A sutured gall-bladder or bile duct should be packed down upon with gauze to insure external escape of the bile in case of leakage. An oozing surface resulting from the removal of the gall bladder or a portion of the liver should likewise be covered with gauze packing. All operations on the bile ducts should be accompanied by drainage through a gall-bladder fistula. This is true both in the case of healthy and in that of infected bile, but particularly in the latter.

The arrest of hemorrhage is accomplished by separate ligation of large vessels, suture of the substance of the liver, the use of the thermo-cautery, and by gauze packing. The latter is the most effectual means of stopping oozing, and the gauze should be kept in contact with the wounded surface until the bleeding has been permanently arrested. In cholæmic subjects it is necessary that all oozing should be stopped before the abdomen is closed, otherwise secondary hemorrhage may be the result.

The Different Diseases which Call for Surgical Treatment.—The diseases of the liver and its ducts which are most frequently the object of surgical treatment are: I. Hepatic abscess; II. Echinococcus cyst; III. Tumors; IV. Cholelithiasis.

Abscess of the liver when single and not of pyæmic variety may be successfully treated by operation. The nature of the operative procedure will depend upon the location of the abscess. A suppurative focus situated near the inferior surface, in the left lobe, or already pointing anteriorly is best reached through an incision in the abdominal wall. An abscess located in the convexity of the organ may require the transpleural route. The position of the abdominal incision will be governed by the probable location of the abscess, and, in case the abscess forms a bulging, the incision will be made over the most prominent part of the swelling. In case the abscess wall is adherent to the parietes it is opened without entering the general peritoneal cavity, and the whole procedure is rendered very simple. The different layers of the abdominal wall are divided down to the abscess wall, an aspirating needle is introduced to verify the nature of the contents, and a knife is then thrust in. The cavity is washed out with decinormal salt solution and a drainage tube introduced. If the abscess is not adherent to the abdominal wall the choice may be made between an operation in one sitting and two separate operative sittings. In the former case the part of the liver in ques-

tion is brought into the wound and surrounded by sterile gauze packing. The general peritoneal cavity having been protected in this way from the possibility of infection, the abscess cavity is opened by means of a pointed knife or the thermo-cautery. The cavity may be irrigated with decinormal salt solution and a drainage tube or gauze packing inserted. The discharge being free for the first few days, the wound requires frequent dressing, but after a couple of weeks the cavity begins to diminish in size and the discharge gradually ceases. Final closure of the sinus may take two or three months or an even longer time. In case of operation at two separate sittings the liver surface is brought in contact with the abdominal wound and either sutured into the same or preferably surrounded with gauze packing. From three to six days later, adhesions having formed which shut off the general peritoneal cavity, the abscess cavity is opened and drained as above. This latter operation is the safer of the two, but a septic condition of the patient may require an immediate opening of the abscess. The latter, on the other hand, may have such an unfavorable location that the general peritoneal cavity cannot be protected during an operation at one sitting, and here a delay of several days, in order to give time for the formation of adhesions, is absolutely indicated. In case an abscess has ruptured into the peritoneal cavity causing general suppurative peritonitis, the usual radical treatment for this condition is adopted.

If the abscess is so far under the ribs as to be out of reach through an abdominal incision it may be necessary to employ the transpleural method. This consists in first resecting two or more ribs and then suturing together the parietal and diaphragmatic pleural layers over a small area so as to shut off the general pleural cavity. These layers and the diaphragm are then incised and, if the latter is adherent to the liver, the abscess can be opened at once. If the liver is not adherent to the diaphragm the parietal and visceral layers of the peritoneum are sutured together, thus shutting off the peritoneal cavity before the abscess is opened. In either case the abscess cavity is drained by means of a rubber tube brought out through the thoracic wound. In place of sutures for uniting the pleural and peritoneal surfaces gauze packing may be employed and adhesions obtained in this way. A third sitting will then be necessary for finally opening the abscess.

The mortality of operations on abscess of the liver has diminished with the earlier recognition of the condition and the improvement in the technique. In case the patient's condition has not been too seriously impaired by the septic absorption, the prognosis is good in the case of a single abscess, even though its location is not the most favorable for its drainage. Thorough protection of the peritoneal cavity by gauze packing, or operation after the formation of adhesions, should prevent peritonitis. Early operation will obviate sepsis.

Echinococcus of the Liver has been subjected to a great variety of methods of treatment, no one of which has proved itself perfectly satisfactory. The older methods of puncture, with or without injection of irritating substances into the sac, and the establishment of a fistula by means of a trocar or tube, have become obsolete. The usual surgical procedure at present consists in opening the abdomen, bringing the involved portion of the liver into the wound, and incising the cyst at once, or after the formation of adhesions. The cyst cavity is then washed out and drained. This procedure has the disadvantage that the whole sac is left behind and the resulting fistula has in some cases been a permanent one. To avoid this, other operations have been devised of late. A procedure which gives excellent results without a fistula consists in enucleation of the mother cyst, cleansing of the fibrous capsule with dry gauze, and complete obliteration of the cavity by suture. Delbet's "capitonnage" consists in emptying the contents of the sac, removing its chitin membrane, and excising as much as possible of the sac wall. The walls are then invaginated and the opposed surfaces sutured. Any form of complete excision of the cyst is difficult and may become a dangerously bloody operation. Some cysts are more favorably located than others for this form of treatment. Partial excision may, however, be comparatively easy and bloodless. The margins are then sutured into the abdominal wound and a drainage tube is inserted.

Tumors of the liver are seldom amenable to cure by operation. Carcinomata, both the primary and the secondary forms, constitute the most common variety. Secondary carcinoma offers a hopeless prognosis, and operative treatment is usually out of the question. Primary carcinoma is very rare and can be cured only in the very earliest stage. As this stage seldom gives rise to objective symptoms, the proper time for operating is usually missed and an exploratory laparotomy is all that is undertaken. In case an operation is decided upon it consists in removal of the growth with the portion of liver affected. The resulting wound may then be partially sutured and packed. The hemorrhage, which is usually severe, is treated by ligation of the larger vessels, cauterization, gauze packing, and sutures. A large portion of the liver can be successfully removed in this way and permanent cures after operation for primary malignant tumors have been reported.

Another method of dealing with the stump of the liver is to bring it out through the abdominal wound and treat it extraperitoneally. The bleeding from it can here be controlled by a permanent clamp, gauze packing, ligatures, etc. This is a less desirable method, however, as it is more likely to be followed by infection of the peritoneum and by hernia. Before the portion of liver is excised the whole of the organ may be encircled by a rubber tube and the hemorrhage temporarily arrested.

After the tumors have attained a large size, formed glandular enlargements, or produced cachexia, operation is contraindicated.

Cholelithiasis.—Stones in the gall passages are the most frequent abnormalities of the liver requiring surgical interference. The condition of cholelithiasis may give few or no symptoms during life and yet at autopsy the gall bladder may be found filled with calculi. The presence of symptoms depends in general upon inflammation or mechanical obstruction of the gall bladder or gall passages. In other words, the appearance of symptoms always means that the stones have produced more or less severe pathological changes in the gall passages, —changes which may or may not be curable by medical means. The latter are uncertain and should not be too long continued when the symptoms do not improve or attacks of obstruction or inflammation become more frequent. The indications for operation have been extended of late years and the tendency of even the more conservative is to operate early. It seems but reasonable to relieve an individual of the stones as soon as possible after the onset of symptoms and before the serious complications have arisen which so frequently accompany gall-stone disease. The results of incarceration in the common duct, perforation of an empyema into the peritoneal cavity, and persistent cholæmia are so unfavorable even with operation that it is wise to operate before they have become possible. The choice of the method of operation can usually not be made until the abdomen is opened and the conditions are disclosed. No one form of procedure can possibly fulfil the requirements of every case, and the surgeon must be prepared for any operation, from a simple opening of the gall bladder to incision and suture of a bile duct.

Cholecystostomy.—This is the most common form of operation and the most easy to perform. The abdomen is opened over the gall bladder by means of an oblique incision following the free border of the ribs or a vertical incision on the outside of or through the middle of the rectus muscle. The peritoneal cavity having been entered, any slight adhesions of the gall bladder to the parietal peritoneum or neighboring viscera are freed with the fingers or a blunt instrument. Thick adhesions should be divided with scissors under guidance of the eye. The gall bladder and gall ducts should then be examined for stones by direct inspection and palpation.

If it is decided to remove the stones and drain the gall bladder, the choice lies between an operation in one sitting and two separate operative sittings. The former is the preferable method, and under proper precautions the danger of infecting the general peritoneal cavity from bile is not great. The gall bladder is surrounded by sterile gauze pads, aspirated, and opened. The finger or suitable forceps is passed in through the opening and any gall stones that may be present are removed. If any stone is felt in the cystic duct it should, if possible, be pushed back into the gall bladder and removed. If this is impossible owing to impaction of the stone, it may be necessary to incise the cystic duct (cysticotomy), extract the stone, and suture the opening thus made. The edges of the gall bladder wound are now sutured into the abdominal wound and a drainage tube is inserted. Unless an obstruction has been left behind in one of the ducts the fistula will close after a few weeks. A permanent fistula may require a secondary operation for removal of the obstruction. This operation at one sitting is to be preferred to that in two sittings when the gall bladder is accessible and can be readily brought into the abdominal wound. When this is not the case, as in a small contracted gall bladder, it may be necessary to pack down upon the latter and delay incision for several days until adhesions have formed. Another method in such cases is to insert into the gall bladder a long drainage tube, surround it with gauze and bring it out through the abdominal wound. The chief advantage of the operation in one sitting over that in two is that the interior of the gall bladder and cystic duct can be better explored before the former has been stitched into the abdominal wound and any stones lodged in its depths more readily removed.

Cholecystostomy carries with it the possibility of a permanent biliary fistula. Mayo Robson reported fourteen such cases out of one hundred and eighty-nine cholecystostomies. When this is due, as in most of the cases, to a stone impacted in the common duct, a second laparotomy may be necessary, and the common duct opened and sutured. Painful adhesions may also be left behind after the operation, and these in rare cases will require a secondary operation for their removal.

Ideal cholecystotomy is the name given to an operation consisting of opening the gall bladder, removing the stones, and suturing the incision. It obviates the disagreeable effects of the fistula and shortens the time of healing. It is in most cases, however, a questionable procedure, as stones can easily be left behind in the folds of the gall bladder or the cystic duct, and the advantages of drainage of the bladder and ducts are lost. It must be remembered that most cases of cholelithiasis requiring operation are complicated by inflammation of the bile passages of a more or less severe degree. The best means of overcoming this is to allow the infected bile to drain off through the gall-bladder opening. In the so-called ideal operation this is not done and the inflammatory condition inside persists, thus predisposing to the future formation of calculi. It is only in the exceptional cases of uninflamed gall bladder that the ideal operation is permissible, and in such cases the results are good. A modification of this method consists in attaching the sutured gall bladder to the abdominal wound so as to prevent leakage into the peritoneal cavity in case the sutures give way.

Choledochotomy, or incision of the common duct, is the most difficult procedure which the surgeon may be called upon to carry out in performing an operation on the gall passages. It is indicated in the case of a stone impacted in the common duct. The presence of a stone in this duct can be detected by direct palpation of the duct. The forefinger of the left hand is inserted into the foramen of Winslow and the thumb is placed upon the structures in the lesser omentum. Very soft concretions may be crushed with the fingers and their passage into the duodenum thus made possible. The use of padded forceps for this purpose is, however, to be avoided, as serious injury to the wall of the duct may be the result. If the stone is too hard to crush with the fingers, it may be pushed onward into the duodenum and the incision thus avoided. If incision is decided upon, the field of operation is carefully protected with gauze pads. The easiest point at which one may reach a stone in the common duct is above the pancreas, and, if possible, the stone should be brought to this place by manipulation. A longitudinal incision is made in the distended duct over the stone and the latter extracted. Two rows of sutures are now inserted and the incision is tightly closed. The sutures may be advantageously introduced before the stone is removed. Halsted has devised a special apparatus for facilitating the insertion of the sutures. It consists of cylinder-shaped pieces of metal of different sizes for insertion into the duct, and a handle attachment which gives a support and allows the duct to be drawn somewhat up into the wound. To insure safety in case of leakage, it is always advisable to carry a gauze drain down to the line of suture. It is usually a good plan to drain at the same time the gall passages by performing a cholecystostomy. This has the further advantage of lessening the tension on the sutures in the common duct. Should the gall bladder be contracted, or its wall seemingly impaired by inflammation, its removal may be indicated provided the common duct is patent throughout. When a gall stone is impacted near the duodenal end of the common duct and cannot be reached through the suprapancreatic portion of the duct, it may be removed by transverse incision of the duodenum followed by suture. This is a most difficult procedure, but has been accomplished successfully a number of times. As impaction of a stone in the common bile duct is almost always accompanied by severe jaundice, the tendency in this latter condition to capillary oozing must be remembered. Only by careful arrest of all bleeding before closing the abdomen can one be sure of preventing serious secondary hemorrhages.

Cholecystectomy, or excision of the gall bladder, is a radical and in many cases a most satisfactory method of dealing with gall-bladder disease. It is contraindicated in case the common duct is closed by a calculus. It finds its chief indications in cases in which the gall bladder is so shrivelled and atrophied as to have become useless as a reservoir for bile, or in those in which the walls of the bladder are extremely inflamed or necrotic. By some surgeons it is considered the operation of choice, as it removes the source of the whole affection, obviates a fistula, and is less likely to leave behind troublesome adhesions. On the other hand, it is a more difficult operation than cholecystostomy and there is greater danger from secondary hemorrhage. The operation consists in enucleation of the gall bladder from its attachments to the liver and ligation of the cystic duct. The excision may be begun at the fundus or the apex. In the former case the parietal peritoneum is divided over the bladder, the latter stripped off from the liver by means of the finger or blunt scissors, and finally the cystic duct is reached and tied off with the artery accompanying it. The separation from the liver is in most cases performed without serious hemorrhage. The bleeding can usually be controlled by gauze packing or by the application of the thermo-cautery. Care should be taken not to work into the substance of the liver. The duct and its artery must be securely tied so as to prevent leakage of bile or a hemorrhage. By beginning with ligation of the duct the process of enucleation may be reversed. The wound surface left by the excision is packed down upon with gauze which is brought out through the abdominal wound. In order to prevent the hemorrhage, associated with separation of the wall of the gall bladder from the liver, it has been advised to leave that portion of the bladder behind and remove or destroy with the cautery its mucous-membrane covering. This is necessary only in exceptional cases, as with care the bladder wall, particularly when diseased, is stripped off without great difficulty, and the oozing can be controlled by gauze packing.

Cholecystenterostomy means the establishment of a

communication between the gall bladder and the intestinal tract. It is resorted to in cases of obstruction from a stone or a stricture inside the duct or from a tumor or adhesions pressing on the duct from without. A stone may be so situated in the duct that its removal is impracticable. Furthermore, the duct with its stone may be so surrounded and embedded in adhesions that it cannot be reached. In these cases cholecystenterostomy takes the place of choledochotomy. Obstruction of the duct from without is usually the result of carcinoma of the head of the pancreas or of chronic productive pancreatitis. In the former case the operation becomes a purely palliative one and death usually results in a short time from the continued growth of the carcinoma. In case of chronic productive pancreatitis the establishment of an outlet for the pent-up bile will react favorably upon the inflammation in the head of the pancreas and a diminution in the enlargement followed by re-establishment of the outflow through the common duct may be the result. The operation has a high mortality, particularly in malignant cases, as the individuals are usually in bad general condition, and the pronounced cholæmia predisposes to serious or fatal hemorrhage. Furthermore, there is always the possibility of infection of the gall passages after the establishment of this direct communication between the gall bladder and the intestine. The anastomosis is made preferably with the duodenum, but if this is impracticable a loop of jejunum is selected. The colon is used only in exceptional instances. The union may be made by means of sutures only, but this is a tedious and difficult procedure. The Murphy button shortens the time of the operation very considerably, and is easily inserted. Subsequent contraction of the orifice with return of the symptoms is possible.

The indications for this operation are becoming fewer since choledochotomy as now performed can be successfully employed in most cases of obstruction due to calculi. It still has a limited usefulness in cases of malignant and inflammatory strictures, but its mortality will necessarily remain a high one, particularly in the former cases. To lessen the danger from hemorrhage, in patients with pronounced cholæmia, Mayo Robson gives chloride of calcium in thirty-grain doses for two or three days previous to the operation.

Selection of the Operation and Indications.—The choice of the operation will, as has been said, be made in most cases after the abdomen has been opened. A radical operation is, generally speaking, the one to be chosen, provided the patient can stand it. If the patient's condition is bad, simple drainage of the gall bladder may be done first and a more complete operation performed at a more favorable time. If stones are found in the gall bladder, associated with previous inflammatory processes and adhesions, or with acute cholecystitis and a seriously damaged condition of the bladder, cholecystectomy is the operation of choice. Painful adhesions even without stones may demand cholecystectomy. Closure of the cystic duct accompanied by hydrops or empyema should be treated by cholecystostomy with cysticotomy if necessary. Chronic closure of the common duct by a stone or carcinoma requires either choledochotomy or cholecystenterostomy. Acute closure of the common duct by a stone should be treated medically at first, and an operation should not be performed until it is evident that the stone is not going to pass of itself, or until the symptoms have become too urgent for delay. Acute cholecystitis may be treated expectantly during the attack if the symptoms are not too severe. After the attack the gall bladder should be explored, as there always remains behind a certain amount of infective material which will eventually give rise to thickening of the gall-bladder, adhesions, inflammation of the ducts, etc. The indications here are much the same as in appendicitis. An operation in the interval is, if possible, to be chosen in preference to one during the attack.

Medical treatment, while of service in many cases of cholelithiasis, should not be tried for too long a time. Constantly recurring attacks of pain which diminish the working capacity of the individual are a sufficient indication for operation, even though no objective symptoms are present. At other times internal treatment is from the outset hopeless, and the favorable time for operating should not be allowed to pass through unnecessary delay. Such cases include acute suppurative cholecystitis and chronic closure of the cystic ducts or the common duct. Exploration at least is advisable in the presence of persistent symptoms on the part of the biliary passages. Should a condition of affairs be disclosed which precludes the possibility of a cure or which would entail a prolonged and dangerous operation, some palliative measure, such as drainage of the gall bladder, will probably be of service to the patient. The exploration, generally speaking, does no harm and may, by disclosing the real condition of affairs, lead the way to successful treatment.

Cirrhosis of the Liver has of late been the object of operative treatment in an increasing number of cases. It has been found that the ascites associated with cirrhosis may be limited in amount and even cured by the establishment of an anastomosis between the portal circulation and that of the branches of the inferior vena cava. The operation is usually performed after repeated tappings have given no permanent result, and the patient is rendered miserable by the distention of the peritoneal cavity with fluid. The abdomen is opened above the umbilicus in the median line, or at the outer border of the rectus muscle. After a portion of the fluid has escaped, the right lobe of the liver, the spleen, and the parietal peritoneum are vigorously rubbed with dry gauze or scarified with some pointed instrument. The great omentum is then stitched to the scarified parietal peritoneum across the front of the abdomen. The object sought for is the formation of adhesions between the surface of the liver, spleen, and omentum, and the parietal peritoneum. Through these adhesions an anastomosis is brought about between the congested portal system and the veins of the abdominal wall which belong to the vena cava system. The abdominal incision is closed with sutures and a separate opening made above the pubes for the insertion of a drainage tube for carrying off the ascitic fluid. The drainage tube is left in place for several weeks and is then removed. Tappings may be required for some time afterward, but their frequency gradually diminishes. In the best results the fluid ceases to collect within the cavity. This operation has not yet become firmly established, but the results encourage further trials. The mortality at present is comparatively high, owing chiefly to the poor condition of the individuals operated upon and the greater risk of infection of a damaged peritoneum. The patients who have recovered have shown in most instances improvement and in a few cases a cure. The autopsy of cases fatal after a period of several months has usually demonstrated the existence of the anastomosis sought for, large veins being found in the artificial adhesions. As ascites usually represents an advanced stage of the disease, and as the progress under medical treatment affords no hope, the operation seems justifiable. If cases are selected which are not too far advanced and do not have complicating disorders of other organs, the mortality of the operation will be lessened and the chances of a cure will be improved. Stricter asepsis and more careful after-treatment should diminish the dangers of infection. *Benjamin T. Tilton.*

LIVER, DISEASES OF: SYPHILITIC INFLAMMATIONS.—Historical.—The existence of syphilitic disease of the liver was denied by Morgagni. Dittrich, in 1849, gave the first comprehensive description of the disease, the tumor-like formations of which had been previously confused with malignant and other new growths. Virchow has placed our knowledge of hepatic syphilis where it now stands.

Classification.—As with syphilitic affections in general we recognize the acquired and congenital lesions. The lesions of syphilis in the liver belong to the tertiary period of the disease; in fact, outside of the occasional occurrence of jaundice in the efflorescent or

early stage due to uncertain lesions, secondary hepatic affections in syphilis are not recognized.

PATHOLOGY.—1. *Acquired Syphilis.*—Two forms are most commonly met with—(*a*) A diffuse syphilitic inflammation affecting the interstitial tissue, not readily distinguished from ordinary cirrhosis. The cell proliferation is markedly interacinous, and is said to run between the columns of liver cells oftener than is the case with alcoholic cirrhosis. The same tendency to shrinking (atrophy) is seen.

(*b*) The much more common gummatous hepatitis occurs in the form of numerous nodules, varying in size from a millet seed to a walnut, of a reddish-gray to whitish-yellow color, irregular, often striated, more or less sharply outlined. The centres of the syphilomata are yellowish-white, caseous, dry, but firm, much more so than a tuberculous caseous mass. These growths tend to develop on the upper surface of the liver, at the attachment of the ligamentum suspensorium, and in the connective-tissue prolongations of Glisson's capsule (peripylephlebitis syphilitica, Schüppell). Microscopically, the fresh red-gray growths consist of round and spindle cells in a homogeneous ground substance; the older caseous areas show masses of fatty necrotic material. The amount of fat and the absence of giant and epithelioid cells are points of differentiation between gumma and tubercle. Alterations of the blood-vessels in these areas, consisting of marked thickening of the medial and adventitial coats, are constant features. Hepatic scars, usually considered to be healing fibrosing gummata, are among the common lesions of acquired syphilis; the extent to which they may deform a liver by their contraction is well known. The possibility, however, of these scars being due to causes other than syphilis is now admitted (Flexner). The gummatous form may be found in connection with the interstitial form. Thickening and adhesions of the liver capsule (perihepatitis) occur constantly with the former condition, and fat infiltration and amyloid degeneration of the liver cells are common. By many, amyloid degeneration of the liver is classed as a form of syphilitic alteration.

2. *Congenital Syphilis.*—The diffuse infiltration is the form most frequently met with; it may occur at any time after the sixth month of fœtal life. The liver is usually much enlarged, often equalling six per cent. of the body weight, firm and tough, gray-red to dirty yellow-gray in color, and the lobular markings are usually obliterated. Occasionally the organ may be excessively icteric (brimstone liver). If the infants survive for a sufficient length of time cirrhotic changes may ensue, with consequent atrophic appearances. Syphilis hereditaria tarda affecting the liver, and appearing first in adolescence, can hardly be distinguished from atrophic cirrhosis. Microscopically, there is first hyperæmia with capillary engorgement, massing of leucocytes, and proliferation of the capillary endothelium; later, in the widened interstices of the lobules, are seen round cells in newly formed connective tissue, and the same cells are frequently found inside the lobules, between the capillary walls and rows of liver cells, and in the walls of the blood-vessels. In the later stage connective tissue replaces the round-cell infiltration, and the liver cells, after some nuclear proliferation, shrink and atrophy. If (which is rather rare) the gummatous form occurs, the liver presents multiple miliary formations. An increase of connective tissue, in the form of small circumscribed areas in addition to the diffuse process, may resemble a gummatous condition. As already mentioned, with the exception of a transient jaundice seen occasionally in the secondary stage, syphilitic hepatic affections are distinctly tertiary, and are usually met with years after the formation of the primary lesion; cases of hepatic syphilis developing six and nine months respectively after infection are reported by Key and Biermer. In both the acquired and the congenital disease the liver is one of the organs of the body most frequently affected.

SYMPTOMATOLOGY.—Jaundice has been mentioned as a symptom in the secondary stage. Many cases of hepatic syphilis are revealed only at autopsy; the more marked cases of the gummatous form show the familiar enlarged knotty and deformed liver, the symptoms in fact being frequently only such as are dependent upon pressure; jaundice is rare in this form of the affection; ascites, due to compression of the portal vein, occurs, and may give the picture of hypertrophic cirrhosis. It may be stated that ascites does not occur in the gummatous form unless the portal circulation is obstructed or the kidneys are vitally affected, but it is more or less to be expected in the general cirrhotic form. The general condition usually suffers, and anæmia and cachexia are more or less marked, sometimes so much so that malignant disease may be suspected. The general diffuse form (syphilitic cirrhosis) presents the picture more or less absolutely of alcoholic cirrhosis, though it is said to be more acute and more rapid in its course, and may speedily terminate fatally. It is remarkable, however, to what an extent a liver may be deformed without giving rise to symptoms. Periods of improvement apart from specific treatment are not infrequently seen; and, on the other hand, even after a supposed cure, relapses and severe after-effects may develop.

In the *congenital form* the symptoms are those of malnutrition, and the infants die after a short existence. Enlarged liver and spleen, anæmia, and cachexia are always present (see above).

DIAGNOSIS.—Gummata may be confused with carcinomatous nodules; the diffuse cirrhosis gives rise to conditions not to be distinguished from an alcoholic affection; but congenital hepatic syphilis is unmistakable.

TREATMENT.—Specific treatment (mercury and iodides) is always indicated, and even in late stages mercury should be employed. Under the influence of this drug gummata may completely vanish, an ascites may disappear, and other severe symptoms may quickly subside. Scar tissue and amyloid change naturally cannot be affected by any treatment. Iron and arsenic are necessary for the anæmic conditions.

John H. Musser.
Norman B. Gwyn.

LIVER, DISEASES OF: TUBERCULOSIS.—See THE APPENDIX.

LIVER, PHYSIOLOGY OF THE.—The position of the liver with regard to the circulation is a sufficient indication that its primary function is to cause chemical modifications in the products of digestion which have been taken up from the gastro-intestinal tract, before these are allowed to pass on into the general blood stream for the nutrition of the other tissues of the body. Although important chemical changes occur in these substances in their passage through the columnar cells of the intestinal wall, further changes of both a qualitative and a quantitative character are required before the portal can be allowed to mix with the systemic blood, and these final chemical transformations have their seat in the liver cells.

Hence the liver becomes the final safeguard of the organism from absorbed products which have not undergone complete assimilation; but its physiological importance by no means ends in carrying out this primary function, for it is also the chief metabolic laboratory of the body in which the greater part of the work of purification of the blood, from either extraneous or excessive dissolved substances—or its standardization, so to speak—is accomplished. It is by the liver cells that the degradation products of proteid metabolism in other tissues are prepared for excretion by the kidneys; here also the final products of the breaking up of the hæmoglobin molecule, after being robbed of their iron which is retained and conserved by the liver cells, are either cast out of the circulation in the bile, or prepared for removal by the kidneys in the form of urinary pigments; here too the quantity of carbohydrate entering the systemic circulation is adapted and regulated to the needs of the organism, by a system of chemical storage, and according to some authors is at least in part united with partially disintegrated proteid rests to form proteid molecules anew, and so spare the amount of fresh proteid required from without in order to maintain tissue equilibrium.

In addition to these important operations many other chemical changes doubtless go on in the liver cells which we have not yet been able to follow out experimentally because of the inherent difficulties of such investigations, and hence it must be admitted that the physiology of the liver forms one of the most fragmentary chapters in our knowledge of biological change. Even in those instances of hepatic activity which have just been enumerated, we know merely the end results because of the crudeness of our methods of study, and are ignorant in great measure of the links in the chemical chains of transformation which occur in the cell.

It may be pointed out that such important chemical changes, as occur in the liver, require a high state of activity on the part of the liver cells, and hence it becomes necessary that an extra stream of pure blood in abundant quantity shall be supplied to the organ in addition to that carried from the intestine, in which not merely has the oxygen been largely used up in the intestinal capillaries, but also further vitiation has resulted from the addition of foreign constituents arising from intestinal absorption.

Such a supply of pure blood is even more necessary in the case of the liver than in that of the lungs to which similarly in the body a large stream of venous blood is carried, for in the first place the hepatic cells are more physiologically active structures of a secretory type, while the endothelial cells of the pulmonary alveoli carry out a much more passive function, acting to a great extent as physical membranes; and, in the second place, the venous blood of the portal system is more heavily charged with substances foreign to the circulation and capable of acting as protoplasmic poisons.

The liver is hence supplied with arterial blood by the hepatic artery, and in addition the blood coming from the area of absorption is diluted, so to speak, as regards the products of absorption, by admixture with the *splenic* blood. This is a function of the spleen which has not hitherto been brought into prominence; but it furnishes an easy explanation of the peculiar position of the spleen with regard to the portal circulation, of the well-known anatomical fact that the blood supply of the spleen is much larger than the metabolic wants of that organ demand, and also of the increased size of the spleen and of the vigor of its rhythmic contractions during the period of digestion. By this anatomical arrangement of the spleen and its vessels as an adjunct to the portal circuit, a supply of blood which has not been materially vitiated by metabolic changes can be directly mixed with the portal blood coming from the intestinal area, before it is sent on to the hepatic cells, for the interposition of the resistance of the splenic capillaries and splenic spaces lowers the arterial pressure down to that of the portal vein. On operative removal of the spleen compensation probably takes place by means of an increased supply of blood through the hepatic artery.

The chief experimental methods by which the functions of the liver have been investigated are the following: 1. Investigations of the chemical composition of the organ and of its secretion, the bile, under varying conditions. 2. Histological and microchemical examination of the liver cells. 3. Comparative analyses of the blood in the portal vein and hepatic vein as indicating the changes which the blood has undergone in passing through the liver. 4. Studies of the effects of excision of the liver in certain animals, and also of short-circuiting it from the portal circulation by means of an artificial fistula established between the portal vein and inferior vena cava. 5. Observations on the changes in substances added to whipped blood as a result of perfusion through the excised liver.

1. Chemical Composition.—The liver tissue resembles other tissues in being alkaline during life and turning acid after death, the acidity being usually ascribed to the formation of sarcolactic acid. There is a certain amount of rigor or post-mortem hardening always developed accompanying the change in reaction, but this is not due to myosin formation since myosinogen is absent from the uncoagulated extracts of the fresh gland.

The proteids of liver have been investigated by Plösz and by Halliburton who found the following coagulable proteids present: (1) A proteid coagulating at 45° to 50° C. which has all the usual properties of a globulin, and is not probably intrinsic to the liver, being indistinguishable from the cell globulin of Halliburton, which is found in most cellular tissues. (2) A nucleo-proteid which coagulates at 60° to 70° C. and possesses most of the common properties of the class excepting that it is not readily salted out of solution, and hence the sodium chloride precipitation method of Halliburton cannot be utilized for its preparation. (3) A globulin coagulating at 70° C. (4) Traces of albumin.

In addition, the liver contains traces of gluco-proteids which probably are derived from the connective-tissue elements, and also, like other tissues, traces of enzymes.

It has been claimed by some that a very appreciable amount of an amylolytic enzyme is present, which has been held responsible for the conversion of the liver glycogen into dextrose (*vide infra*), but other observers deny the existence of sufficient amounts of such an enzyme to accomplish this function and ascribe the conversion of glycogen to the activity of the cell protoplasm.

Undoubtedly the most interesting of the proteid bodies of the liver, are those which contain iron, since it is the presence of these in the liver substance, taken in conjunction with the chemistry of the bile pigments, which conclusively proves the important hæmatopoietic function exercised by the liver cell.

That practically all the iron contained in the liver cells is present in some organic form, is shown by the fact that the tissue reacts to the ordinary reagents for inorganic iron, such as potassium ferrocyanide or sulphocyanide, only after treatment by an inorganic acid, such as hydrochloric or sulphuric. The presence of iron may be demonstrated either microchemically or by making extracts of the tissue with dilute hydrochloric acid.

There are two distinct types of organic iron-containing compounds found in the liver. One of these is in the form of iron albuminates, which are characterized by the fact that the iron may be separated from the albumin by the action of inorganic acids. That these are simple salt-like compounds of albumin with iron is demonstrated by the fact that they are practically identical in their properties with salts artificially prepared by the action of oxide of iron on alkali albumin. Such artificial compounds of iron under the name of ferratins have been introduced into therapeutics, with the idea that from their resemblance to the naturally occurring iron albuminates of the liver they would be probably more readily absorbed. Such ready absorption from the intestine is claimed for such compounds, on, however, very dubious experimental grounds. There is a certain amount of evidence that if hæmoglobin is under any circumstances built up from such albuminates as are found in the liver, it is only intermediately through the second class of iron compounds found in the liver cells, which contain phosphorus in their composition and belong to the class of the nucleins. Such iron-containing nucleins were first demonstrated in the liver by Zaleski, who, under the view that only one such iron-containing nuclein was present, applied to it the name of "hepatin"; there is little doubt now, however, that several different iron-containing nucleins are present in the liver cells, and hence the name "hepatin," if preserved, would be better applied as a class name for these substances.

The iron-containing nucleins are distinguished from the iron albuminates by their behavior toward acid alcohol to which they yield up none of their iron; they also are stained black by alkaline sulphides only after long standing, and, in short, are not simple salts of iron like the albuminates, but *true* organic compounds of iron in which that element is directly united to carbon. It is for this reason that the reactions proper to iron salts are shown only when the nuclein molecule containing the iron is disintegrated.

It has been shown by Bunge, and workers in his laboratory, that it is these iron-containing nucleins which are

chiefly concerned in the manufacture of hæmoglobin in the body, and he accordingly terms them "hæmatogens." This has been demonstrated by the hatching of eggs in the yolk of which "hæmatogens" or iron-containing nucleins are the only form of iron present and from which alone the hæmoglobin present in the bird on hatching can arise. The same has been shown by feeding new-born mammals entirely upon egg yolk and iron-free food, and also by analyzing the total iron in ingesta and egesta, when the former contained iron only in the form of nucleins; it has thus been shown that the iron-containing nucleins or "*hæmatogens*" are directly absorbable from the intestine. It is hence supposed that the hæmatogens are absorbed, carried to the liver, and after undergoing certain obscure metabolic changes in that organ are carried to the red marrow where they form, in the erythrocytes, building material for hæmoglobin. (See article on *Blood, Formation of the*, vol. ii., p. 19.)

The total quantity of iron in the liver is very variable, averaging about 2 parts per 1,000. It is present in three to four times as great quantity in the liver of the new-born as in the full-grown animal, a reserve being so provided for the period during which milk is the only food, because this is very deficient in iron. The quantity stored in the liver is increased by any circumstance which leads to destruction of red blood corpuscles, and hence it is found to be very high in pernicious anæmia.

The bile pigments, from their close chemical relationship to hæmoglobin, furnish another proof of the important part taken by the liver in the metamorphoses of hæmoglobin in the body.

The liver is under normal conditions very rich in fats, and in bodies of a phosphorized character containing fats, such as *lecithin* and *jecorin*. Of these, the latter-named body was first isolated from the liver by Drechsel, who at that time thought it was exclusively found in that organ, but it has since been identified by Baldi as a constituent of spleen, muscle, and brain.

The total ether extract of liver is stated by Noel Paton as five per cent. of the undried gland, which is equivalent to twenty per cent. of the dried weight. This ether extract contains according to the same author an amount of fatty acid varying from forty to ninety per cent., and on an average the amount of fat unassociated with phosphorized bases may be placed at three per cent. of the fresh weight. The amount is increased by feeding richly on either fats or carbohydrates, and it is probable that on carbohydrate feeding a fairly large percentage of glycogen is slowly changed into fats by the action of the liver cells, and later carried to the connective tissues, instead of being converted into dextrose as is usually taught, and then discharged into the blood stream. The liver fats contain less olein and hence have a higher melting point than those found in other tissues. The percentage of ether extractives is reduced much less rapidly during inanition than is the percentage of glycogen.

The amount of lecithin is surprisingly high, reaching as much as 2.5 per cent. of the fresh organ, or over ten per cent. of the total solids; while cholesterin is very low, averaging only 0.03 to 0.04 per cent. of the gland (Noel Paton).

Jecorin is contained in the liver in considerable quantity. It is closely allied in character to the protagons found in the tissues of the central nervous system.

The carbohydrate contained in the liver when the organ is examined in the fresh condition is present almost exclusively in the form of glycogen or animal starch, a body belonging to the group of polysaccharides; but when the liver is allowed to remain for some time before examination, and especially if it be kept warm in the interval, the glycogen is found to have been, wholly or in part according to the percentage present, converted into glucose.

The amount of glycogen present in fresh liver varies within wide limits; by somewhat prolonged and excessive feeding upon carbohydrates it may be raised as high as seventeen per cent., and, as a result of prolonged inanition, it may be reduced to the merest traces. It is formed most readily from ingested carbohydrates, and under normal conditions it is probable that these are its chief if not its only source; but it has been shown that, in the absence of carbohydrates, a formation in the liver of glycogen from proteid may occur if this form of food-stuff be fed to the animal in excessive amount. There is, on the other hand, no clear experimental proof that it can be synthetized in the liver cells from fats.

Glycogenesis.—There have been many volumes written, and much discussion waged as to the sources, uses, and fate of the glycogen of the liver.

The simplest view is the one originally advanced by Claude Bernard which gives expression to what is usually termed the *glycogenic function* of the liver. This theory is still advocated in its entirety by many physiological chemists, but others nowadays are beginning to see reasons for modifying it to a certain extent.

According to this theory the glycogen of the liver solely carries out the function of acting as a temporary storage of excessive carbohydrate supplies. All the glycogen arises from dextrose and it all passes back again into dextrose; the effect of the backward and forward transpositions being to maintain as nearly as possible a constant percentage of dextrose in the circulating blood. When the percentage of dextrose in the blood rises above a certain normal level, amounting to about 0.15 per cent., the excess of sugar acts as a stimulus to the liver cells causing them to transform the circulating sugar into glycogen and so keep down the percentage in the blood to somewhere near the normal level. On the other hand, when no sugar is being absorbed, and that contained in the circulating blood is being gradually decreased by oxidation processes going on in the tissues, then a reverse stimulus is given to the liver cells, which causes them to change the stored-up insoluble glycogen into soluble dextrose which passes out into the blood stream and so tends to keep up the percentage, and send carbohydrate nutriment to the other tissues of the body.

There is sufficient experimental evidence to prove to a demonstration that this is the primary, and probably the most important, use of the glycogen storage in the liver; but at the same time there is also convincing evidence both that glycogen can be formed by the liver from other sources than dextrose, and also that by no means all the glycogen formed in the liver is reconverted into dextrose, for a certain amount is certainly converted into fats, and a further portion is in all probability united with nitrogenous organic substances, derived from partially disintegrated proteid, to regenerate proteid once more.

The chief experimental evidences in favor of the *glycogenic function* of the liver may be enumerated as follows:

1. The glycogen is most abundantly formed in the liver cells when carbohydrate food is given, it is formed in only small quantity on a liberal proteid diet, and is probably never produced from fat; also the amount of glycogen in the cells increases with the time which has elapsed after a meal rich in carbohydrates.

2. The glycogen contained in the liver cells is after death converted rapidly into dextrose, and such an action is probably due to the exaggerated activity of the asphyxiated and dying liver cells.

3. A similar disappearance of glycogen occurs during a period of inanition, the amount which has disappeared being proportional to the time which has elapsed, and during this period the amount of circulating dextrose is kept up close to the normal value. Hence the most probable explanation is that the blood is being continuously supplied with dextrose from the stored-up glycogen of the liver.

4. The kidneys tolerate only a certain percentage of dextrose in the circulating blood and commence to secrete urine containing dextrose when this low level of about two parts per thousand is exceeded. Hence, did the liver not store up the dextrose in some form, it would reach the systemic circulation, and so the kidneys, and be nearly all excreted in the urine and lost to the body. That this is the true explanation of the prevention of glycosuria after a carbohydrate meal is perhaps most

clearly demonstrated by slowly injecting a strong solution of glucose in whipped blood, under like conditions, in one case into the central end of a mesenteric vein and in the other into the central end of a systemic vein, such as the jugular. In the former case, no glycosuria occurs because the liver cells store up the sugar; but, in the latter case, glycosuria follows immediately, obviously because the sugar in excessive amount reaches the general circulation and so the kidneys, before it can be taken up by the liver cells.

5. Direct analyses of the blood of the portal and hepatic veins, (*a*) during carbohydrate absorption, and (*b*) during inanition, have demonstrated that in the former case the blood passing to the liver contains more carbohydrate than that leaving the organ, while in the latter case the reverse condition is observed. Here it must be remarked, however, that the blood supply to the liver is so copious as to render the difference in percentage small even when a large transference of material may be taking place. Further, the rate of removal of carbohydrate from the liver is never so great as the rate of its storage during the assimilation of a heavy carbohydrate meal, and hence, although the differences in percentages of portal and hepatic blood are sufficient to demonstrate storage in the liver, they are quite insufficient according to many observers to prove that this stored carbohydrate is again set free as dextrose.

There is then no room for doubt that the excess of dextrose carried to the liver by the portal vein is stored as glycogen for the time, and it appears clear that under usual conditions a great deal of this stored glycogen is again given back to the blood as dextrose, but it will be observed that there is absolutely no proof that *all* the glycogen is disbursed in this form.

The glycogen of the animal has been compared to the starch of the vegetable world, and this undoubtedly good comparison ought to help to make it clear that the glycogen may serve as a constructive raw material and not merely as a source of energy by combustion. It has been suggested by Pavy that a considerable conversion into fat may occur in the liver. Some hours after a meal rich in glycogen-forming elements, it is always found that the fat content of the liver cells has increased at the expense of the glycogen, and this is accomplished at a period when the plasma is perfectly clear from suspended fat, showing that the fat accumulation is probably not due to infiltration. Hence it is probable that, at any rate, when the glycogen storage is high, fat is formed in the liver from glycogen. Fat so formed may afterward be distributed to the connective tissues and stored therein.

It is impossible to give any such direct proof of the generation of proteid from glycogen in the liver, because an abundance of proteid is always naturally present in the protoplasm of the cells and in the bathing fluids, and accordingly even did granules of a protoplasmic nature appear in the cell after a heavy glycogen storage their source would not be clearly known. But it has been argued by Pavy from the great power as proteid sparers which the carbohydrates exercise, as shown by the enormously reduced amount of proteid upon which nitrogenous equlibrium can be maintained when carbohydrates are liberally supplied, as well as from the fact that carbohydrate can be isolated from practically any form of proteid by appropriate chemical treatment, that the glycogen of the liver is converted into proteid, and that the nitrogenous part of the proteid molecule can be used as a carrier for it. In fact Pavy regards this as the most important function of the glycogen storage, and it is, according to this observer, as a result of this office of the liver cells passing into abeyance that diabetes ensues.

Such a view furnishes an easy explanation of the persistence of dextrose in the urine, even after all carbohydrate has been cut off in the food. For if we regard the proteid molecule as a union of a carbohydrate with a nitrogenous rest, then it is easy to see how the vitiated metabolism of the liver cells may, by a simply reversed process, set free dextrose from the circulating proteid. In accord with this view is also to be easily placed the observed fact that in severe diabetes the output of nitrogenous material as urea is largely increased.

To sum up, then, the glycogen is placed at the command of the liver cells, which can probably use it for the manufacture of dextrose, fat, or proteid according to the wants of the organism as expressed by the condition of the circulation.

The liver contains more urea than any of the other organs and the quantity is increased during active proteid metabolism, as on a diet rich in proteid, or during proteid absorption; thus pointing toward that active formation of urea in the gland which has been proved by other methods (*vide infra*). Uric acid and the purin bases, such as xanthin, hypoxanthin, and guanin, have also been shown to be present.

The bile salts and bile pigments are formed in the liver cells, but it is certain that the former undergo a circulation in the intestine and tissues and are in great part carried each time to the liver cells in the circulating plasma. The lecithin and cholesterin of the bile are also probably excreted by the liver cells, although some hold, on rather insufficient evidence, that the latter substance is secreted by the gall bladder.

2. Histological Examination.—Microscopic examination of the liver cells under varying conditions with regard to the period of digestion demonstrates that glycogen first begins to accumulate in the form of minute granules at a period of three or four hours after a carbohydrate meal, and at a later stage as the amount of glycogen increases the granules fuse together to form amorphous masses, which when abundant give to the cell protoplasm the appearance of an open network. In the starving animal, the glycogen granules completely disappear in a period of about three days, the outer zones clearing first, and the area around the nucleus last.

The glycogen granules are best shown by staining microchemically with iodine which strikes a brown color with the glycogen.

In a normal liver, fat is always present in the form of minute granules, which may be demonstrated to be fatty in nature by staining black with osmic acid. The fat granules are most abundant in the outer or portal zone of the liver lobule, on which account when present in excessive amount they give rise to the well-known nutmeg appearance of the fatty liver. These granules are increased either immediately after a fatty meal, or some hours after a carbohydrate one, in which case they are formed at the expense of the glycogen which is first present.

The presence of the organically combined iron of the liver cells may be shown by different microchemical methods, such as treatment by the alkaline sulphides, by acids followed by either potassium ferrocyanide, or pure hæmatoxylin dissolved in distilled water.

That no inorganic iron, or iron simply combined as a salt with albuminate, is present in normal liver except in the fœtal condition, is shown by the negative results obtained by either the ferrocyanide method or the hæmatoxylin method, unless previous treatment by acid is employed which decomposes the organic compounds of iron. The treatment with acid is effected by placing the tissue in one part of hydrochloric or sulphuric acid to nine parts of alcohol, at a temperature of 35° C. for from one to twenty-four hours (Macallum). Then the acid may be removed by washing in alcohol, and the iron demonstrated by the ferrocyanide or hæmatoxylin method. The latter method is strongly recommended by its discoverer, Macallum, as giving perfectly permanent stains of a striking blue or blue-black color, which is only given by inorganic iron, and is apparent even when only traces are present such as cannot be demonstrated by the ferrocyanide or ammonium sulphide methods. This method may further be used for the demonstration of iron in extracts of the gland.

3. Comparative Analyses of the Blood in the Portal and Hepatic Veins.—The value of this method

is minimized by the rapid rate of the blood flow through the liver, as a result of which it is possible to show a reliable difference in composition only when the amount of substance being taken up from the blood or dissolved and added to it is large. It is in fact only in the case of the deposition of carbohydrate during active absorption that the method has given results which are trustworthy. Under proper conditions of experimentation the amount of dextrose in the portal and that in the hepatic blood are practically identical; so that Seegen's results (in which he found in this condition more dextrose in the hepatic than in the portal vein, thus apparently directly proving the re-solution of the glycogen) have not been substantiated by other observers. The method cannot be used in the case of either proteids or fats. Observations have been made by this method which appear to show an increase in the amount of urea in the hepatic blood above that in the portal during proteid absorption, when urea formation in the liver cells is probably proceeding at a maximum rate. A similar result, but in the reverse direction, is found in the case of ammonia which is said to be present in between three and four times as great quantity in the portal as in the hepatic blood.

4. Excision and Short-circuiting of the Liver.—By the application of these methods it has been shown that urea is formed in the liver, and considerable information has also been gleaned concerning the end products of nitrogenous metabolism from which it is here synthesized. The surgical difficulties standing in the way of the removal of the liver in mammals were for a long time regarded as insuperable, for if the organ be simply removed without making provision for the continuance of the portal circulation, the stasis of the blood in the whole intestinal area gives rise to such severe shock that the animal succumbs almost immediately as a result of the operation. In birds, however, the vein of Jacobson gives rise to an anastomosis between the portal vein and the *vena advehens* of the kidney, so that when the portal vein is tied between the liver and the junction of this vein, the blood coming from the intestinal area can be carried through the *vena advehens* and hence stagnation does not occur.

Minkowski took advantage of this anatomical relationship and tied the portal vein in this situation in geese. In some animals the portal vein only was tied, and in others the liver was subsequently excised. As a result of the operation, the uric acid in the urine, which in birds takes the place of the urea of the mammal, fell from representing sixty to seventy per cent. of the total nitrogen as in normal animals, until it represented only three to six per cent., while at the same time ammonium lactate, which is not present in normal bird's urine, appeared in sufficient amount to account for the deficit in urates. The lactic acid simultaneously produced is sarcolactic acid and is produced in somewhat greater quantity than is necessary to combine with the ammonia, so that the urine becomes acid. When the uric acid has reached the minimum given above, the ammonium lactate forms more than half the total solids. No change took place in the urea, showing that the small amount of this substance present in bird's urine is not formed in the liver, and the kreatinin also remained undisturbed. Lactic acid, leucin, and tyrosin were found in the blood. Injected urea was not changed in the blood but appeared in the urine as such, whereas in the normal goose it appears again as uric acid.

The ligature of the hepatic artery alone, in birds or mammals, leads to a temporary replacement of uric acid and urea respectively by ammonium lactate, this result being probably due to defective oxidation.

The total removal of the liver from the circulation or eventually from the animal was first rendered feasible by the operative procedure of Eck, a Russian surgeon, who found it possible to establish a fistula between the portal vein and inferior vena cava, whereby the portal blood system is drained directly into the vena cava without first passing through the liver. The liver could then either be left *in situ* or afterward removed. In those animals in which it was left *in situ* no great disturbance of nitrogenous metabolism occurred except immediately after the operation, or when the animals were given either excess of proteid food or ammonium salts in their food. Then it was found that convulsions ensued, and excess of ammonium salts and carbamate of ammonium appeared in the urine. In those animals in which the liver was also removed results similar to those given by Minkowski were obtained, viz., decrease in the urea and its replacement by ammonium compounds.

5. Perfusion through the Excised Liver.—These experiments are performed by placing cannulæ in portal vein and hepatic vein, and running whipped blood (which is arterialized each time after passing through) under a pressure somewhat greater than that of the portal vein during life through the blood-vessels of the excised liver. The effects of adding different chemical substances to the whipped blood can then be determined.

The percentage of urea in whipped blood taken from an animal recently fed upon proteid, is increased when it is led through an excised liver, and Schröder, who by applying this method first conclusively proved that urea is formed in the liver and not in the kidneys, found that when ammonium compounds were added to whipped blood which was afterward circulated round an excised liver, the ammonium compounds so added became decreased in amount and were replaced by urea. Similar results were not obtained by perfusion through the limbs or other organs, and hence it was proven that urea is formed in the liver, and further that it is formed from ammonium compounds, a result which corresponds with that obtained by studying the effects of excision of the gland. *Benjamin Moore.*

LIVINGSTON ARTESIAN WELL.—Sumter County, Alabama.

Post-Office.—Livingston. Hotels.

Livingston, the county seat of Sumter County, is located on the Alabama Great Southern Railroad, a part of the Queen and Crescent route operating, with numerous connections, between Cincinnati, Ohio, and New Orleans, La. The town is situated on a sandy plateau with perfect under-drainage. The climate at Livingston furnishes a fair type of the atmospheric conditions prevailing in central Alabama. The warmest weather recorded by standard signal service instruments for many summers has been 97° F., and this elevation has been very rare. The coldest weather noted in winter has been 20° above zero. The average temperature of the year is 63° F., and the average rainfall fifty-six inches. Geologically, the well is located at the extreme southern outcrop of the cretaceous limestone, which forms the basis of the rich belt of prairie land extending through middle Alabama. It pierces the entire thickness of the limestone stratum to reach the underlying sandstone formation in which the water is procured. The depth of the well is 1,087 feet and the flow of water one gallon per minute. It was bored with a view to obtaining a supply of good drinking-water, but it proved decidedly saline, and at first the venture was thought to have been a useless expenditure of time and money. By degrees, however, the citizens began to use it, and though at first disagreeable to the taste, it soon became a favorite beverage. Certain medicinal effects were observed, especially in dyspepsia and chronic bowel disorders, and little by little the well finally acquired considerable local celebrity. The water is beautifully clear and limpid and effervesces actively when drawn from the spout. The specific gravity of the water is 1.003, and its temperature, which does not vary at any season, is 68° F. From the circular issued by the town authorities we have obtained the following analysis by an unnamed chemist:

One United States Gallon Contains:

Solids.	Grains.
Silicic acid and silicates	1.14
Iron bicarbonate	.20
Magnesium bicarbonate	2.32
Calcium bicarbonate	7.14

Solids.	Grains.
Iron perchloride	0.19
Magnesium chloride	1.84
Calcium chloride	2.98
Potassium chloride	.33
Sodium chloride	295.43
Strontium chloride	Trace.
Sodium bromide	.98
Total	312.55

Gases.	Cu. in
Free carbonic acid (in solution)	21.47
Carbonic acid in combination as carbonates	9.32
Total gases	30.79

This water possesses aperient, tonic, and diuretic properties. It is said, furthermore, to have a decided alterative influence on the economy. According to Dr. R. D. Webb, of Livingston, who has made a special study of the water for many years, it is highly beneficial in cases of chlorosis, malarial anæmia, affections involving the alimentary tract, the kidneys, and the bladder, and in nervous exhaustion. *James K. Crook.*

LOBELIA.—INDIAN TOBACCO. "The leaves and tops of *Lobelia inflata* L. (fam. *Lobeliaceæ*) collected after a portion of the capsules have become inflated" (U. S. P.). This is an annual herb from 20 to 50 cm. (8 to 20 in.) high, with an upright, branching, leafy stem and thin ovate, nearly or quite sessile, slightly hairy leaves. Inflorescence composed of spike-like racemes, terminating the strongly excurrent stem and the branches, and making altogether a lax pyramidal, leafy panicle. Flowers small, consisting of a five-toothed calyx adherent to the ovary and becoming markedly inflated in fruit; a labiate corolla with a narrow tube open on the apparently upper side to its base, and a five-lobed border of which the two lobes next the fissure are erect, narrow, and pointed, the other three broader and spreading; stamens, five, syngenesious, ovary two-celled with innumerable microscopic ovules. Seeds very fine, light-brown, oblong, with a handsome reticulated testa. All parts of the plant contain, when fresh, an acrid, milky juice, and have an exceedingly sharp, peppery, tobacco-like taste. The seeds are rather more active than the rest of the plant and have been used separately. Lobelia is an abundant pasture weed, growing in most parts of the United States. The knowledge of its use was received from the aborigines, and is several centuries old.

FIG. 3227.—Lobelia inflata; Flowers and Fruit. (Baillon.)

COMPOSITION.—The most important ingredient of lobelia is the alkaloid *lobeline* ($C_{16}H_{24}NO$), "an oily yellowish fluid with a strong alkaline reaction, especially when in solution. In the pure state it smells slightly of the plant, but more strongly when mixed with ammonia. Its taste is pungent and tobacco-like, and when taken in minute doses it exercises in a potent manner the poisonous action of the drug. It dissolves in water, but more readily in alcohol or ether. It neutralizes acids and forms, with some, crystalline salts." Several of these salts are listed by manufacturers. Although volatile, it is decomposed by a high heat. Lobelia contains also *essential oil* and a doubtful substance, *lobelacrin*, probably a compound of lobeline and *lobelic acid*.

ACTION AND USE.—This herb has had in times past an extensive employment in this country at the hands of irregular practitioners of the "Thompsonian" school, and the more modern "Eclectics." Despite its very active and dangerous qualities, it is still not infrequently called for as a family medicine. Regular physicians have never used it extensively, but neither has it been altogether neglected by them. It was in far more frequent demand fifty years ago than it is now. It is a nauseating expectorant, or a depressing emetic, much resembling tartar emetic. The nausea is primarily due to gastric irritation, and full doses are liable to be promptly vomited. Smaller doses produce burning and pain in the stomach, followed by nausea, lassitude, or depression, commonly cold perspiration and pallor, dizziness, rapid and weak respiration following temporary slowing. These systemic symptoms bear a general resemblance to those of tobacco sickness, whence the common name of the plant. The secondary nausea, often with painful and obstinate vomiting, is at least partly of central origin. There is no considerable increase of respiratory secretion, but spasmodic conditions, as of asthma, are relaxed. When the action is prolonged, as by repeated doses, the depression is profound, and there is paralysis of respiration, frequently with convulsions, dependent thereon. In children there are sometimes earlier convulsions, due to abdominal pain. Respiratory failure is the common cause of death. Gastric perforation has frequently occurred, with other indications of intense abdominal inflammation.

There have been two uses for lobelia, namely, as an emetic and as an antispasmodic of the depressing sort, applied chiefly to respiratory affections. As an emetic, it was formerly a common household remedy, used for the most trivial purposes, and fatal poisoning was common. This use is almost obsolete, being only occasionally resorted to in spasmodic croup. Its use in very small doses, combined with expectorant drugs, is still considerably resorted to, and is of advantage. If vomiting is desired, a full dose (gr. xx.–xxx.) should be given; otherwise the dose should be small (gr. i. to iij. or v.). Undesirable or dangerous results are most likely from doses just insufficient to cause vomiting, or from moderate doses repeated, so as to produce a cumulative effect. The official preparations are the fluid extract (doses as above, minims for grains), and the twenty-per-cent. tincture, used almost altogether as an expectorant in doses of ♏ v. to xxx. *Henry H. Rusby.*

LOCOMOTOR ATAXIA. See *Spinal Cord Diseases: Tabes Spinalis.*

LODI ARTESIAN WELL.—Fountain County, Indiana.

POST-OFFICE.—Lodi. This is a station on the Indianapolis and St. Louis Railroad, 58 miles west of Indianapolis. The following analysis was made by Dr. J. C. Pohle:

ONE UNITED STATES GALLON CONTAINS:

Solids.	Grains.
Magnesium carbonate	0.66
Calcium carbonate	2.01
Sodium sulphate	2.13
Potassium sulphate	.80
Magnesium sulphate	3.26
Calcium sulphate	55.56
Calcium phosphate	1.20
Sodium chloride	502.46
Calcium chloride	47.93
Magnesium chloride	53.54
Magnesium bromide	.88
Silica	.52
Sulphur	.50
Nitrogenous organic matter	.80
Total	672.25

This is a strong saline sulphureted water and quite analogous to that of the Kentucky Blue Lick waters. *James K. Crook.*

LOGWOOD.—HÆMATOXYLON. *Campechy Wood.* The heart wood of *Hæmatoxylon Campechianum* L. (fam. *Leguminosæ*). This is a small, spreading, irregularly branched tree, with a dark rough bark on the trunk and larger branches, and light-brown, white-spotted twigs. Wood hard and close, divided into a light-colored alburnum and a red heart wood, the whole of the former being

rejected. It is a native of Central America, especially of Honduras and Yucatan. It takes one of its names from Campeche. It is also naturalized and cultivated in the West Indies, where it grows freely.

It is supposed that logwood was used by the aborigines for dyeing before the arrival of Europeans, but this is not known with certainty. It was, however, imported into England in the latter part of the sixteenth century, and shortly after interdicted for a time as yielding poor and fading colors. It was introduced into the London Pharmacopœia about a hundred and fifty years ago.

The collection is simple enough. The trees are felled when the trunks are as large as, or larger than, a man's thigh, the yellowish sap wood is chopped away, and the heart wood cut in billets three or four feet long and dried. In this shape it is imported and sent to the dye mills. When first cut, these logs are of a light-red color, but by exposure to the light and air they become dark-brown, and finally almost black upon the surface, sometimes dark-bronze and iridescent. The inside becomes, in time, a rich reddish-brown. In the course of manufacture it is cut, by heavy machines with rapidly revolving knives, into fine chips, in which condition, or in powder, it is purchased for pharmaceutical purposes. For dyeing purposes, these chips are cured by soaking them in water and then frequently turning them over to expose them to the atmosphere. The chemical changes which ensue largely unfit them for medicinal use. Such chips are distinguished by their dark or blackish metallic green or blue surface. Logwood has a sweetish astringent taste and colors the saliva pink.

Logwood contains about ten per cent. of a sweet-tasting, crystalline coloring substance, *hæmatoxylin,* readily soluble in hot water or alcohol, but nearly insoluble in cold water. It turns red upon exposure to sunlight, and gives violet solutions in the presence of alkalies and air, due to the formation of *hæmateïn.* Melted with potash, it yields pyrogallic acid.

Action and Use.—This substance is infinitely more used in the arts than in medicine, being an important dye and foundation for inks. In microscopical work, the purple solution of extract of logwood, or hæmatoxylin, is a favorite stain, acting with great rapidity and bringing into prominence the nuclei of cells. As a medicine, it is a mild and rather agreeable astringent, useful in subacute diarrhœa of children and in phthisis, but no better than a dozen other astringents, except that its taste commends it to children. The linen is very liable to be stained red when it is used. The extract is official (*Extractum Hæmatoxyli*, U. S. P.), made by exhausting with boiling water and evaporating to solidity.

W. P. Bolles.

LOJA OR LOXA BARK. See *Cinchona.*

LONDONDERRY LITHIA SPRINGS.—Rockingham County, New Hampshire.

Location.—Londonderry.

This spring is evidently not used as a resort, but its waters have become widely celebrated and are extensively sold. The following analysis was made by Prof. H. Halvorson:

One United States Gallon* Contains:

Solids.	Grains.
Calcium sulphate	25.13
Potassium carbonate	18.33
Calcium bicarbonate	7.29
Magnesium carbonate	7.53
Aluminum sulphate	5.05
Lithium bicarbonate	7.29
Iron carbonate	1.85
Potassium sulphate	.30
Sodium chloride	.83
Silica	1.25
Organic matter	None.
Total	74.85

Carbonic acid gas, 62.84 cubic inches.

* The original analysis was estimated in grains per imperial gallon.

The analysis shows a very potent and valuable mineral water, possessing the virtues of an antacid, diuretic, and ferruginous tonic. It has been found beneficial in a wide range of diseases, but notably those due to the uric-acid diathesis. The best effects of the water have been observed in gout and rheumatism, in neuralgic pains, in gravel, and in giddiness, headache, insomnia, and other manifestations denoting the lithæmic state. Being entirely free from organic matter, the water is well adapted for domestic use. Although not used as a resort, the proprietors of the spring extend a welcome to visitors and are pleased to show them through their extensive bottling plant.

James K. Crook.

LONGEVITY.—(L. *Longævus*, of great age, aged, from *longus*, long, and *ævum*, an age, the life of a man.) The word longevity has two meanings. It is sometimes used to designate the natural duration of life,—the length of life that an organism might attain if not destroyed by accident nor attacked by disease. The usual meaning of the term, however, is the duration of adult life beyond the ordinary limit, or the attainment of extreme old age.

The idea of a natural duration of life involves the question of natural death. This question is discussed fully elsewhere (see *Death, Physiological Theories of*); but it may be noted here that, while most physiologists are of the opinion that each organism begins its existence endowed with a capacity for living only to the end of a definitely limited period, this limit has never been determined and its existence is purely hypothetical. The evidence for such a limit is obtained, first, from the well-known facts that organisms on the average do not persist as individuals beyond a certain period, the average duration of life being characteristic for each species, and that likewise for each species there is a certain extreme duration of life beyond which no individual has been known to exist.

Secondly, there are observations like Minot's on the growth of guinea-pigs (see *Growth*) which show that at the beginning of individual existence an organism possesses certain functions at a maximum of efficiency, and that this efficiency begins to decline at once, rapidly at first, and then more and more gradually, until death ends all functions.

Thirdly, we have the line of evidence that has produced probably the most impression. This is furnished by the experiments of Maupas on Infusoria. Maupas found that if Infusoria were fed, but prevented from conjugating, they would continue to multiply by fission for a large number of generations. But at length this power of growth and multiplication would become impaired, and finally the organisms would become so weakened as to lose all power of multiplication and death would follow. But this catastrophe could be averted by allowing the Infusoria to conjugate with others of a different stock (see *Impregnation*). Then there was a rejuvenescence and the organisms would begin life anew with fresh vigor. These experiments of Maupas, then, seem to furnish at the same time a demonstration of natural death and an explanation of the importance of sexual reproduction. According to this view, by the union of two gametes, or of an egg and spermatozoon, the protoplasm acquires a supply of "vitality" that is gradually dissipated by the activities of the organism. The somatic cells of the higher forms must finally use up their vitality and die, but the species is prevented from becoming extinct by the sexual cells, which are set apart in order that they may undergo rejuvenescence by conjugation with similar cells from another individual, and thus begin a new cycle of life. But Maupas' results have not passed without adverse criticism. Besides Weismann's criticisms (see this Handbook, vol. iii., p. 381), we have the experiments of Joukowsky, who reared several species of Infusoria for many generations without conjugation. He observed a culture of *Pleurotrichia lanceolata* for eight months and during that time four hundred and fifty-eight generations were produced entirely by fission. And we have the very recent experi-

ments of Calkins upon *Paramœcium caudatum,* which he has reared through from three hundred and sixty to four hundred generations and apparently may continue indefinitely by the simple expedient of a change of diet. He finds that Paramœcium passes through more or less regular cycles of activity and weakness. The period of weakness ends in death provided the diet (the bacteria in hay infusion) remains the same. But a change of diet to beef extract restores the weakened functions of growth and division without conjugation. Moreover, he finds that conjugation alone does not produce rejuvenescence, for normal conjugation between two gametes fed on hay infusion does not restore the weakened activities, if the same diet is continued, but is soon followed by death. But a change of diet to beef extract for a time results in normal life and activity.* Finally, in the Amœba and Bacteria we have examples of unicellular organisms in whose life history conjugation appears never to have occurred, and the banana is an example of a multicellular organism of complex structure utterly incapable of sexual reproduction and which has probably been so for a long period, and yet its protoplasm continues to grow and multiply asexually with full vigor. Moreover, in man himself it is not clear that old age and death are due to any inherent property of the living substance. A man is said to be as old as his arteries. But the stiffening of the arteries is due to the increase of connective tissue or the deposition of inorganic salts. This interferes with the proper adjustments of blood pressure and disturbs the nutrition and respiration of the cells. The consequent weakening of functions is as much the result of the action of the environment and as little inherent as the poisoning effect of bacterial products or other injuries in disease.

"Natural death," then, would seem to be a thing of doubtful existence, and, so long as this is the case, an attempt to discover the "natural duration of life" which it is supposed to terminate would appear to be futile.

Turning to the other meaning of longevity, What is meant by extreme old age? Man is the only organism for which there is a sufficient number of records of the duration of life to supply the necessary data for the statistical study of this question. Pearson has shown that if we take a number of persons born during the same year, say a thousand, and plot the number of deaths of these persons during each succeeding year, we shall obtain a "mortality curve," which, for English males at least, presents two points of maximum frequency. One of these is in the first year of life (theoretically nine months before birth) and the other in the seventy-second year. We are concerned here with the period of most frequent death in old age only. (For the expectation of life at different ages see *Vital Statistics.*) Pearson has resolved the mortality curve for English males mathematically into five component curves. (See his work on "The Chances of Death, etc.") The curve of old-age deaths that Pearson obtained in this way begins very gradually at about the twentieth year and rises to a maximum in the seventy-second. Thence it falls off somewhat more rapidly and ends at 106.5 years. Thus theoretically the extreme limit of human life would appear to be 106.5 years, but, as Pearson remarks, one cannot place much reliance upon this limit, for he found that a slight change in the form of the curve would extend the limit as much as ten years. As a matter of fact, as we shall see later, the extreme duration of human life is apparently considerably greater than that. It will be noticed that this curve is unsymmetrical, or skew, the mean being in the sixty-seventh year. The slope of the curve is measured by a standard deviation of thirteen years and five months, and its skewness is measured by the difference between the mean and the point of maximum frequency which is 0.345 of the standard deviation.

* Later, Calkins has carried his series of Paramœcium without conjugation beyond the six hundred and twentieth generation. At that generation there came a period of depression that beef extract failed to overcome, but the culture was finally restored to full vitality by the application of an extract of calves' brains. Experiments are now in progress to determine what substances in these extracts have this restorative effect upon *Infusoria.*

These results enable one to select a certain duration of life as typical for old men. We may select as our type either the mean of this curve, sixty-seven years, or its mode, seventy-two years; and we may define *longevity* as the duration of life beyond this typical limit.

In the Report of the Massachusetts State Board of Health for 1897, Dr. S. W. Abbott gives tables of the frequency of deaths of both males and females at each year of age from 0 to 100 based upon the returns of the State census of 1895 and the reported deaths from 1893 to 1897. Curves plotted from these tables are similar in form to Pearson's mortality curve for English males. In Abbott's tables the maximum frequency for adult males is in the seventy-second year, and for adult females it is in the seventy-third year.

That the attainment of longevity is not infrequent is shown by the following figures taken from the final report of the eleventh census of the United States.

TABLE I.—DEATHS DURING THE CENSUS YEAR ENDED MAY 31ST, 1890. MALES.

Ages.	Number of deaths.	Rate per 100,000 deaths.
All ages	458,992*	100,000
60 to 65	19,746	4,302
65 to 70	20,012	4,360
70 to 75	19,625	4,276
75 to 80	16,418	3,576
80 to 85	11,460	2,497
85 to 90	5,834	1,271
90 to 95	1,998	433
95 and over	811	177

It will be noticed that in this series the maximum occurs between the sixty-fifth and seventieth years of age.

These figures are not very reliable, especially because many infant deaths are probably not reported, which would make the rates per 100,000 somewhat too high. Yet they serve fairly well to show the relative frequency with which the different degrees of old age are attained in this country, including various sections and all races. Lady Glenesk has tabulated the ages at death reported in the obituary column of the *Morning Post* (London) during the ten years from 1887 to 1896. She counted in all 76,806 deaths, of which 10,806, or 14.5 per cent., were at 80 years or over, and were distributed as follows:

TABLE II.—DEATHS ADVERTISED IN THE *Morning Post*, 1887–1896, AT EIGHTY YEARS AND OVER.

Age.	Number of deaths.	Age.	Number of deaths.	Age.	Number of deaths.
80	1,333	89	490	97	54
81	1,196			98	35
82	1,200	90	385	99	23
83	1,069	91	277		
84	1,040	92	233	100	10
		93	185	101	5
85	807	94	128	102	11
86	818			103	3
87	754	95	86	104	1
88	587	96	74	105	2

Arranging these deaths in five-year groups and calculating the rate per 10,000 reported cases, we obtain the following results:

TABLE III.

Ages.	Number of deaths.	Rate per 10,000 deaths.
80 to 84	5,838	760
85 to 89	3,456	455
90 to 94	1,208	159
95 to 99	272	36
100 and over	32	4

It will be noticed that in this list thirty-two persons, or four in ten thousand, are credited with having lived a hundred years or more.

* Total number of deaths of males at known ages.

In addition to these, Lady Glenesk tabulated the deaths of centenarians reported in the news paragraphs of the

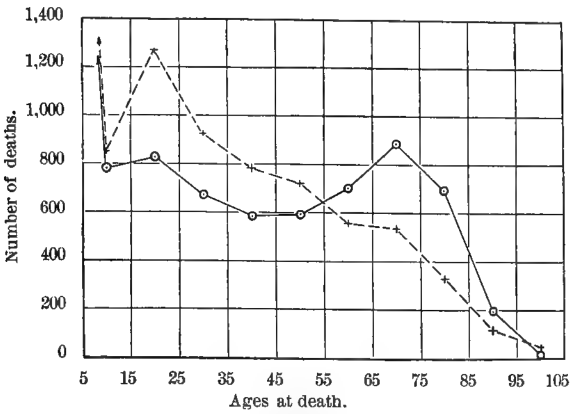

FIG. 3228.—Comparison of the Mortality Curves of Colored Males (dotted line) and Native-Born White Males having Both Parents Native Born, the continuous line showing the relative frequency of deaths per 10,000 deaths of each race at various ages grouped in ten-year periods. (Calculated from data of the Eleventh United States Census.)

Morning Post from 1887 to 1896. There were 233 of them, distributed as follows:

TABLE IV.

Ages over.	Number.	Ages over.	Number.
100	50	107	7
101	32	108	4
102	33	109	8
103	23	110	12
104	20	"Upward of 100"	15
105	14		
106	15	Total	233

There are on record a number of persons who are reported to have lived over one hundred and ten years. Tracy cites the case of Noah Raby at the Piscataway poor-farm, in New Jersey, who is said to be (in 1902) one hundred and twenty-nine years old; and Lady Glenesk gives a detailed account of Marie Durand Girard, known locally as "La Mère Girard," who according to the parish register of St. Just-de-Claix (Isère, France) was born September 22d, 1760. She celebrated the hundredth anniversary of her marriage on the 13th of January, 1885, that is in her one hundredth and twenty-fifth year. The date of her death is not given, but seems to have occurred during that year.

It is not safe, however, to place much reliance upon the exactness of records of extreme old age. This was demonstrated by some results obtained in connection with the New York State census of 1875. The records of persons reported in 1875 as over a hundred were traced back through three censuses. The following table, quoted from Tracy, gives some examples of the results obtained:

TABLE V.

Numbers of cases.	AGES RETURNED.			
	1860.	1865.	1870.	1875.
1	79	83	96	102
8	82	80	94	100
9	80	100	94	108
22	78	80	96	101
36	78	90	97	105
44	56	70	70	100
46	65	90	97	102

It seems probable that the large number reported at 110 in the table from the *Morning Post* is due to a combination of the tendencies to exaggerate old age and to report ages in round numbers.

That longevity is greater among women than among men is demonstrated by statistics. For example, comparing the deaths of men and women over 80 years of age in proportion to the total deaths of men and women respectively at known ages reported in the eleventh census of the United States, we find of men 4377.6 per 100,000 and of women 5257.4 per 100,000. The same thing is shown by the tables of expectation of life. The Massachusetts table for the years 1893–97 gives for women at 75 years of age an expectation of life of 8.29 years, while for men it is only 7.37 years. The corresponding figures in the English table for 1871–80 (Dr. W. Ogle) are 6.87 and 6.34, respectively.

The dependence of longevity upon racial characteristics is brought out very clearly by a study of the returns of deaths in the United States census. In the following table we have compared the number of deaths of white and colored males in ten-year periods. In order to have as homogeneous a population as possible we have taken only white males who were native born and had both parents native born. The census unfortunately does not distinguish between pure bred negroes and those of mixed blood, so our colored population is to that extent heterogeneous. During the census year ended May 31st, 1890,

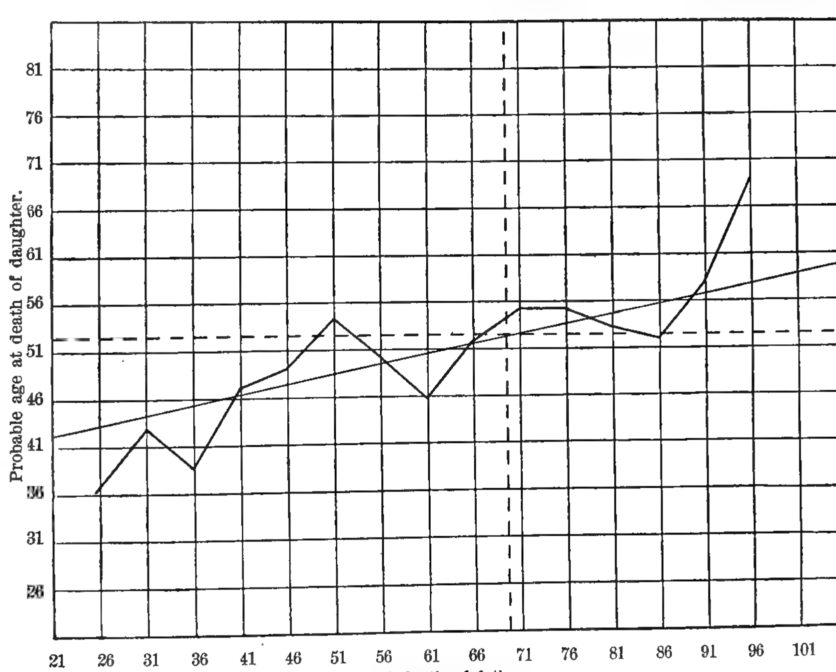

FIG. 3229.—Regression Diagram showing the Probable Age at Death of Daughters of Fathers Dying at Various Ages. (After Beeton and Pearson.)

the total deaths reported of native-born white males of native parentage, of which the ages at death are known, was 159,650. Of colored males the total deaths at known ages was 58,791.

TABLE VI.—DEATHS OF WHITE AND COLORED MALES IN TEN-YEAR PERIODS.

Ages.	White, Native Born. Both Parents Native.		Colored.	
	Number of of deaths.	Per 10,000 deaths.	Number of deaths.	Per 10,000 deaths.
5 to 15	12,464	781	4,992	849
15 to 25	13,229	829	7,476	1,272
25 to 35	10,720	672	5,428	923
35 to 45	9,363	586	4,605	783
45 to 55	9,436	591	4,249	723
55 to 65	11,209	702	3,283	558
65 to 75	14,126	885	3,151	536
75 to 85	11,069	693	1,939	330
85 to 95	83,055	191	676	115
95 and over	179	11	268	46

The results contained in the third and fifth columns of this table are represented graphically in Fig. 3228. The solid line is an empirical mortality curve for American white males, the dotted line a similar curve for colored males, the great infant mortality being neglecthe in both. It will be noticed that the forms of the curves are quite different. The white curve has its maximum in the 65–75 period, corresponding to the experience in England and Massachusetts, and another less marked maximum between 15 and 25. The colored curve has a very pronounced maximum in the 15–25 period, and thence descends in a nearly straight line toward a zero somewhere beyond 95, crossing the white curve at about 55 years. In other words, taking the deaths reported during a single year, it is found that the number of white males who have lived over 55 years is largely in excess of the number of colored males who have lived so long. The exact proportion is as 2,482 to 1,485, or about 5 to 3. That this is not an unusual condition is shown by the fact that similar results were obtained in the previous census.

If longevity is correlated with racial characteristics, we should expect it to be correlated also with family characteristics, that is, we should expect it to be inherited. Miss Beeton and Professor Pearson have demonstrated that this expectation is realized. They have constructed a number of correlation tables and regression diagrams such as are used in the study of the inheritance of stature, eye color, etc. (see *Heredity*, Table I. and Fig. 2,606), but in this case the character taken is duration of life. Fig. 3229 is a regression diagram illustrating the relation between the duration of life of fathers and that of their daughters. The vertical dotted line marks the mean duration of life of all the fathers, and the horizontal one that of all the daughters. The zigzag line connects the means of the arrays of daughters, and the diagonal line is the regression line passing as nearly as possible through the means of the arrays. An inspection of this diagram shows that, in general, the longer the life of the father the longer the daughter may expect to live. If there were no such correlation, the means of the arrays would be most probably the same as that of all the daughters and the regression line would correspond with the horizontal dotted line.

Some of the results of this investigation are given in coefficients of correlation and compared with the theoretical coefficients of heredity for other other characters (see *Heredity*, Tables III. and IV.) in the following table:

TABLE VII.

Relatives.	Coefficient of correlation.	Theoretical.
Father and adult son	0.1353 ± 0.0209	0.3
Father and adult daughter	.1301 ± .0195	.3
Mother and adult son	.1313 ± .0190	.3
Mother and adult daughter	.1493 ± .0202	.3
Adult brothers	.2853 ± .0196	.4
Adult sisters	.3322 ± .0185	.4
Adult brother and sister	.2319 ± .0145	.4

It will be noticed that in the cases of collateral inheritance the coefficients obtained correspond more nearly with the theoretical values than in direct inheritance. This is further illustrated by a comparison of Fig. 3230, with Fig. 3229. Beeton and Pearson explain this phenomenon by the supposition that brothers or sisters are more apt to live under similar conditions than are parents and offspring.

By a comparison of the inheritance of duration of life and the inheritance of other characters, Pearson has been able to calculate how much of the death rate is selective, that is, dependent upon the constitutional pecularities of the people dying, and how much is non-selective, that is, due to purely external causes. He estimates that from fifty to eighty per cent. of the death rate is selective, a result, if confirmed, of great importance for the theory of natural selection (see *Evolution*).

In the course of their studies on the inheritance of the duration of life Beeton and Pearson ran across a remarkable relation between duration of life and position in the family; that is, they found that in general elder brothers or sisters are longer-lived than their younger brothers or sisters, respectively.

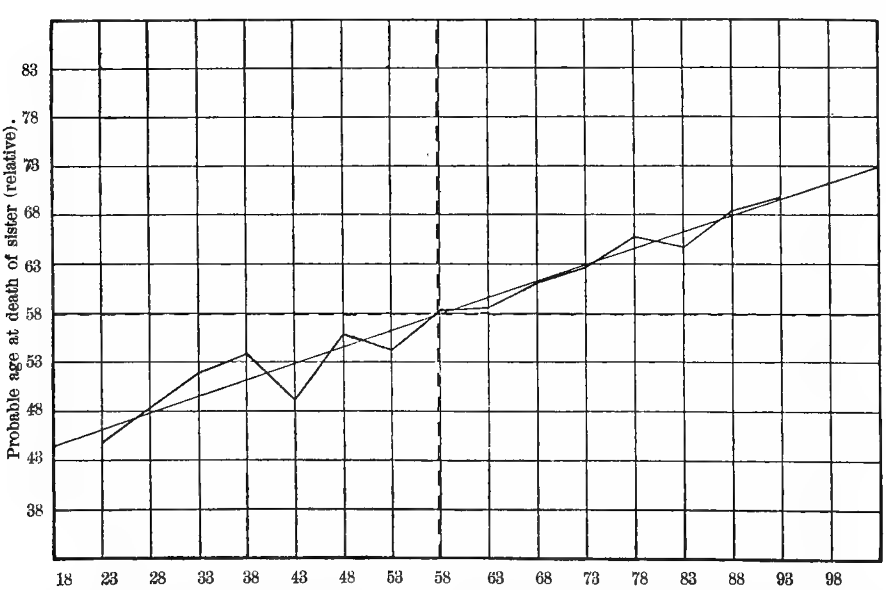

FIG. 3230.—Regression Diagram showing the Correlation between the Ages at Death of Sisters. (After Beeton and Pearson.)

Moreover, they found that, in general, the greater the interval between births the greater will be the difference in the duration of life.

Finally, it is evident that a person dying at an early age cannot leave a large family, but it has been shown (Beeton, Yule, and Pearson, 1901; Powys, 1901) that there is a correlation between size of family and longevity extending beyond the period of child-bearing (Fig. 3221). In the Whitney family of Connecticut, "American Quakers," it was found that the average number of children to each parent increased with the duration of life of both fathers and mothers up to 85 or 90 years. This does not mean, of course, that children were produced at these advanced ages, but simply that there is a correlation between fertility and the qualities that lead to longevity. In England and New South Wales the results are somewhat different, the correlation ceasing for English mothers in the period between 55 and 60 and for mothers in New South Wales between 65 and 70, the same as for English fathers, that is, parents living to these ages have as large families on the average as those living longer.

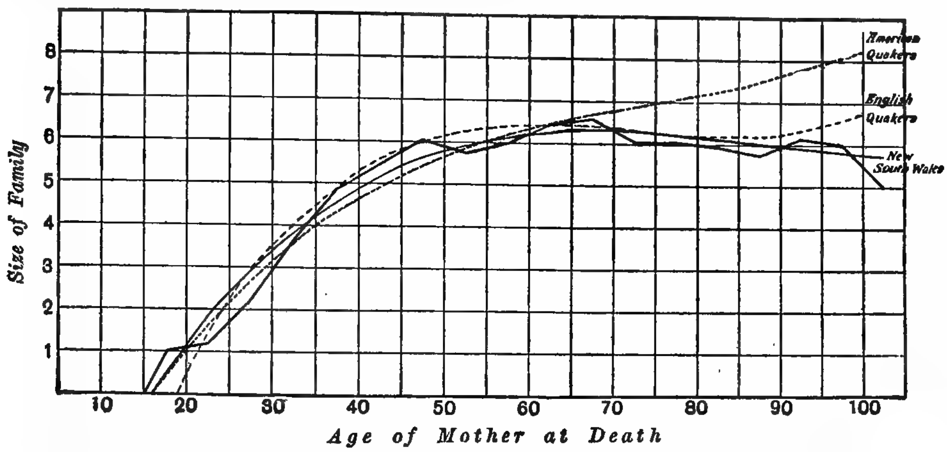

FIG. 3231.—Theoretical Curves for Duration of Life of Mothers and Number of Offspring, America, Great Britain, New South Wales; With New South Wales Experience. (After Powys.)

It will be noticed that this point, where correlation ceases, corresponds very nearly with the age of most frequent deaths of adult white people, and this suggests an explanation of the apparent limitation set upon the length of human life. If a person living a hundred years has no better chance of leaving offspring than one living seventy years, it is evident that natural selection becomes inoperative at seventy, or, rather, those characteristics that tend to prolong life beyond seventy years will not have a selective value so far as the next generation is concerned, and therefore will have no better chance of preservation in the struggle for existence than those which tend to shorten life to the seventieth year. So we may regard human life as limited, not because the living substance is incapable of continued activity beyond a certain number of years, but because the duration of individual existence beyond a certain age is of no advantage to the species.

Robert Payne Bigelow.

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LORANTHACEÆ.—(*The Mistletoe Family.*) A peculiar family of some twenty genera and five hundred species of parasitic plants, mostly of the tropics. They are of great interest to botanists and a number are quite ornamental, but they are of little economic importance. The extremely viscid berries of *Viscum album* L., the European mistletoe, and of other members of the family, are used for making bird-lime. The herbage of this plant has been employed as an antispasmodic from ancient times, but its repute is largely mythical and it is now scarcely used. It contains no substance worthy of note as a physiological agent. American mistletoe, *Phoradendron flavescens* (Pursh) Nutt., of the southern United States, has been considerably employed in doses of 1 to 4 gm. (gr. xv. to lx.), either in infusion or in the fluid extract form, as a substitute for ergot, in labor, as an emmenagogue, and for cerebral congestion. The writer has found various other species of the genus similarly employed, and also as galactagogues, by the natives in various parts of South America.

Henry H. Rusby.

LORDOSIS signifies anterior curvature as distinguished from kyphosis, posterior, and scoliosis, lateral curvature of the spine. Lordosis is curvature with the convexity of the curve directed forward. The term, however, is not commonly applied to opisthotonos. Lordosis is almost always a transient curvature, and probably never has the rigidity which not infrequently attends kyphosis and scoliosis. It is chiefly a compensating curve which may readily be made to disappear. For instance, the lordosis produced in walking down a steep incline or in carrying a heavy weight in front of the body, the "saddle back" of pseudo-hypertrophic muscular paralysis, the lordosis accompanying flexion and ankylosis of the hip-joint, or that seen in the lower part of the spine in Pott's disease may all be made to disappear by changing the position of the body. While the term scoliosis is sometimes used as a synonym of lateral curvature of the spine, neither kyphosis nor lordosis is used to indicate a disease. Lordosis has been made the subject of mechanical treatment, but probably not with any important useful result.

Adoniram B. Judson.

LORETIN—meta-iodo-ortho-oxychinolin ana-sulfonic acid ($C_9H_4IOH, SO_3H.N$)—is a yellow crystalline powder without odor, very slightly soluble in cold water (1 in 1,000) or alcohol, somewhat more soluble in boiling water (about 1 in 200), and insoluble in ether, chloroform, benzol, and oils. Its salts with alkalies are soluble in water, but not those with the alkaline earths. It contains thirty-six per cent. of iodine, but is a very stable compound even in direct sunlight. With ferric chloride it makes a deep green color. By experiments on animals

Ammelburg showed it to be non-toxic in large dosage. But it acts as a powerful germicide, and constitutes an odorless non-toxic substitute for iodoform. It is used as a dusting powder or in five to ten per cent. collodion or ointment, or, as the sodium salt, in one- or two-per-cent. solution. With magnesia it forms a valuable application for burns and eczema. The insoluble calcium salt is used for making "loretin gauze." Fenzling refers to its special applicability in veterinary work. Nicati employed it with boric acid in conjunctival diphtheria.

Loretin-Bismuth is employed in powder, and in the form of a ten-per-cent. ointment or paste, as an application to ulcers, syphilitic lesions, and moist eczema. It has also been given internally for intestinal tuberculosis in dose of 0.5 gm. (gr. viij.). *W. A. Bastedo.*

LOS ANGELES AND PASADENA.—Los Angeles is the largest city in Southern California, containing over 100,000 inhabitants, and is the great business centre of this region. It has grown with great rapidity since 1880, when it had only about 11,000 inhabitants. It lies in a valley upon the western bank of a small river, 17 miles from the Pacific coast. To the northwest is Santa Barbara, 80 miles distant; to the south, San Diego, 125 miles distant; and 350 miles northwest is San Francisco. Many railroads converge here, and it is within easy access of attractive resorts in the mountains, valleys, and on the seacoast. Los Angeles and its suburbs, of which Pasadena is one, possess all the attributes and charm of a town situated in such a climate as Southern California—a luxuriant and varied vegetation, flourishing to a greater or less extent the year through, mild winters with a long duration of daily sunshine, comparatively cool summers, a great preponderance of cloudless weather, and a low rainfall.

The city itself contains many fine buildings, public and private; boulevards shaded by many varieties of tropical and semi-tropical trees, numerous parks, ninety miles of street railway, and a sewer system emptying into the Pacific Ocean. "It is a beautiful and interesting place, full of architectural and social contrasts. Several elements go to make up the city, the Southern or Spanish, and the American; and brown faces, betraying Castilian and Indian ancestry, mingle on the busy streets with those of the fairer-skinned Yankee type. Low adobe quarters and American country houses are found near each other, within a few minutes' walk, although the old-fashioned 'adobe' is growing more rare. Modern office-buildings appear within sound of the bells of the early missions" (Solly). The water-supply comes from the neighboring mountains and is abundant and good. The watering-places of Long Beach, Santa Monica, San Pedro, and Redondo are within easy access of Los Angeles.

The climate of Southern California as a whole has been already discussed in this HANDBOOK under the title *California, Southern,* and the reader is referred to that article.

CLIMATE OF LOS ANGELES, CAL. LATITUDE, 34° 3′; LONGITUDE, 118° 15′.

	Spring.	Summer.	Autumn.	Winter.	Year.
Temperature—					
Average mean	58.4°	67.5°	62.7°	53.5°	60.5°
Average daily range	20.6	23.1	24.5	20.1	22.0
Mean of warmest	69.4	81.3	76.1	64.2	72.7
Mean of coldest	48.8	58.2	51.6	44.1	50.7
Highest or maximum	97.6	100.4	95.3	85.4	94.7
Lowest or minimum	37.9	49.4	40.2	29.3	39.2
Humidity—					
Mean relative	70.4%	69.1%	63.2%	63.6%	66.6%
Precipitation—					
Average in inches	4.28	.02	1.57	8.65	14.52
Wind—					
Prevailing direction	W.	W.	W.	N.E.	W.
Average hourly velocity in miles	5.3	4.8	4.8	5.4	5.1
Weather—					
Average number of clear days	36.2	34.9	52.3	47.9	171.3
Average number of fair days	38.1	50.6	32.5	26.6	144.8
Average number of clear and fair days	71.3	85.5	84.8	74.5	316.1

The preceding table, in connection with what is given in the article referred to, will be sufficient to indicate the principal climatic features of Los Angeles.

"In Pasadena," says Dr. McBride, "the temperature falls steadily from the warmest period, usually 1 P.M., until sunrise next morning. The temperature and humidity, referred to in the following table, were always taken on a northeast porch."

The general characteristics of the climate are those of all this region—one resort differing from another only by the modifications of its situation; warmth, equability, a large amount of sunshine, and a small amount of annual rainfall are the main features. The temperature is somewhat higher in summer and lower in winter than it is at the resorts on the coast. There are frequent fogs in the morning and at night during the spring and summer. The average number of days with foggy nights and mornings for the year is fifty-seven. The highest recorded temperature is 108° F., and lowest 28° F. The humidity is very moderate, 66.6 per cent. for the year. A large number of tourists visit Los Angeles during the year, many of them in search of health; but for the consumptive a large city, however favorable the climate may be, is obviously not the most desirable place. The best season for visiting Los Angeles is said to be from November to May.

Pasadena, a suburb of Los Angeles, is situated in the beautiful San Gabriel Valley, about nine miles distant, at an elevation of nine hundred feet. It is an attractive residential city of about twelve thousand inhabitants. It is twenty miles from the sea and five from the mountains. The soil is sandy and porous, and there is a good supply of water. The climate is essentially the same as that of Los Angeles, though the temperature is a little higher, and the humidity somewhat lower. The mean average temperature for January is 54° F.; for December 58° F. The winter is said to be especially agreeable. From the beauty of its location, the attractiveness of the surrounding country, its social and educational advantages, the excellence of its architecture, its orange groves and vineyards, it is considered one of the most eligible places of residence in Southern California. The accommodations are abundant and good.

Date—1900.	Temperature, Degrees Fahr. At sunrise.	At 1 P.M.	Weather.	Midday humidity. Per cent.
Jan. 1st	51	64	Clear A.M., partly cloudy P.M.	71
2d	54	60	Cloudy; sprinkles	73
3d	55	57	Rain from 6 A.M. all day, 1.09 inch.	
4th	52	64	Fine; some clouds P.M.	73
5th	57	64	Cloudy and sprinkles A.M.; 0.02 inch.	73
6th	50	66	Fine; clouds P.M	73
7th	53	64	Partly cloudy	73
8th	52	64	Fine; high wind P.M	42
9th	51	64	Fine	45
10th	50	66	Fine	42
11th	49	67	Fine	45
12th	53	70	Fine	45
13th	56	71	Fine	
14th	52	66	Fine	42
15th	50	62	Fine	45
16th	47	57	Fine	46
17th	55	72	Fine	45
18th	55	72	Fine	40
19th	57	71	Fine	36
20th	52	67	Fine	43
21st	47	64	Fine	50
22d	49	67	Fine	43
23d	52	68	Cloudy	44
24th	53	66	Cloudy	44
25th	55	61	Cloudy; sprinkles	68
26th	50	64	Clear	63
27th	49	61	Partly cloudy	73
28th	54	60	Partly cloudy	81
29th	51	67	Partly cloudy A.M	76
30th	55	62	Partly cloudy A.M	83
31st	51	63	Partly cloudy A.M	76
Feb. 1st	47	67	Partly cloudy A.M	73
2d	51	63	Partly cloudy A.M	76
3d	47	65	Fair	73
4th	50	58	Partly cloudy and squalls	67

Date—1900.	Temperature, Degrees Fahr. At sunrise.	Temperature, Degrees Fahr. At 1 P.M.	Weather.	Midday humidity. Per cent.
Feb. 5th...	48	59	Cloudy	75
6th...	46	67	Fine	50
7th...	50	64	Fine	44
8th...	48	64	Fine	44
9th...	48	66	Fine	38
10th...	55	67	Fine	31
11th...	53	68	Fine	41
12th...	48	64	Partly cloudy	66
13th...	56	64	Partly cloudy	66
14th...	50	60	Partly cloudy	67
15th...	52	62	Partly cloudy	67
16th...	49	68	Clear	58
17th...	53	75	Clear	43
18th...	57	70	Clear	44
19th...	49	64	Fine	50
20th...	51	65	Fine	60
21st...	52	74	Fine	48
22d...	56	78	(55° wet, 76° dry) =	22
23d...	59	76	Fine	22
24th...	57	75	Fine	22
25th...	55	73	Fine	60
26th...	50	65	Fog early	58
27th...	52	71	Clear	33
28th...	54	74	Clear	26
Mar. 1st...	57	73	Clear	33
2d...	53	68	Clear	44
3d...	55	61	Misty all A.M.; 0.045 inch	74
4th...	51	56	Rain 7 to 1; 7.53 inches	
5th...	45	60	Fine	66
6th...	46	62	Fine	66
7th...	48	65	Fine	66
8th...	51	66	Fine	44
9th...	56	79	Fine	36
10th...	65	83	Fine	32
11th...	68	81	Cloudy	38
12th...	56	70	Cloudy	76
13th...	59	63	Cloudy	76
14th...	57	64	Cloudy	77
15th...	56	72	Cloudy	76
16th...	57	64	Misty; 0.06 inch	88
17th...	57	63	Partly cloudy	66
18th...	56	69	Cloudy	66
19th...	56	62	Misty; 0.10 inch	78
20th...	55	69	Cloudy	68
21st...	55	68	Cloudy	66
22d...	57	63	Misty; 0.02 inch	82
23d...	56	63	Misty; 0.02 inch	78
24th...	51	71	Fine	56
25th...	54	72	Fine	64
26th...	58	68	Partly cloudy	63
27th...	55	67	Clear	54
28th...	51	70	Clear	54
29th...	53	75	Clear	51
30th...	57	79	Clear	53
31st...	57	78	Clear	60
July 1st...	63	72	Fog early	65
2d...	60	73	Fog early	61
3d...	58	73	Slight high fog	61
4th...	57	75	Clear	62
5th...	62	78	Clear, slight high fog	62
6th...	62	78	Clear, slight high fog	62
7th...	64	79	Clear, slight high fog	62
8th...	61	82	Clear; fog	60
9th...	63	82	Fog; fine	61
10th...	65	84	Fog early	56
11th...	65	87	Clear	44
12th...	69	88	Clear	46
13th...	70	86	Fog early; fine	51
14th...	67	78	Fog early; fine	57
15th...	66	78	Fog	58
16th...	66	80	Fog	56
17th...	62	79	Fog	58
18th...	60	78	Fog	58
19th...	61	78	"Eastern atmosphere," evening lightning.	60
20th...	65	74	Sprinkles during day	69
21st...	63	81	Shower clouds	68
22d...	69	89	Fire on mountains broke out; clear.	34
23d...	77	92	Clear	29
24th...	71	91	Clear	35
25th...	66	85	Clear	45
26th...	63	81	Clear	50
27th...	65	78	Slight fog	54
28th...	67	80	Fog slight	62
29th...	64	77	Fog	62
30th...	62	78	Fog early	62
31st...	64	85	Clear	50
Nov. 1st...	59	75	Fine	35
2d...	61	82	Fine	26
3d...	65	86	Fine	19
4th..	65	84	Fine	26
5th..	65	84	Fine	32
6th..	67	83	Fine	32
7th..	64	76	Fine	32
Nov. 8th..	57	73	Fine	40
9th..	62	79	Fine	35
10th..	63	82	Fine	27
11th..	63	83	Fine	27.5
12th..	64	84	Fine	24
13th..	64	82	Fine	26
14th..	60	75	Fine	28
15th..	60	71	Cloudy	75
16th..	57	64	Showery 11 A.M	78
17th..	57	59	Rained 0.86 7 A.M., rained all day.	
18th..	58	62	Rained 1.11 inch; cloudy and sprinkly.	
19th..	57	63	Partly cleared off; 0.06 inch.	
20th..	54	58	Showery last night and all day; 0.62 inch.	
21st...	56	58	Rained all day; 3 P.M. 1.41 inch., 6:15 P.M. 3.24 inches.	
22d...	58	67	Cleared off; 2.02 in.; fog 4 P.M.	
23d...	57	66	Fine	56
24th..	56	72	Fine	49
25th..	60	73	Fine	54
26th..	59	70	Fine	60
27th..	57	72	Fine	59
28th..	55	70	Fine	44
29th..	53	71	Fine	40
30th..	57	72	Fine	42
Dec. 1st...	60	75	Fine	39
2d...	60	72	Fine	38
3d...	59	73	Fine	
4th...	59	75	Fine	40
5th...	61	76	Fine	38
6th...	61	75	Fine	38
7th...	62	76	Fine	40
8th...	60	74	Fine	48
9th...	58	71	Fine	45
10th...	53	63	Fine	58
11th...	50	64	Fine	58
12th...	51	68	Fine	58
13th...	52	67	Fine	51
14th...	52	62	Partly cloudy all day	48
15th...	50	64	Fine	46
16th...	50	68	Fine	44
17th...	54	66	Fine	44
18th...	53	70	Fine	40
19th...	59	72	Fine	36
20th...	56	77	Fine	44
21st...	53	64	Partly cloudy	44
22d...	54	66	Fine	77
23d...	51	68	Fine	41
24th...	52	69	Fine	41
25th...	54	71	Fine	41
26th...	55	67	Fine	51
27th...	48	64	Fine; dust storm 4:30 P.M.; clouds came from S. Bernardino region, east.	58
28th...	51	62	Dust obscures the sun; no wind	34
29th...	49	63	Clear	37
30th...	45	60	Clear	39
31st...	44	57	Clear	30

The preceding table, in which are given the daily temperature, humidity, and weather of Pasadena for the winter months and the month of July of the year 1900, has been kindly furnished the writer by Dr. J. H. McBride of that place; and as it shows, so much better than any compiled and abbreviated report can do, the weather conditions for each day during this period, at this locality—which may serve as a type for other similar localities in Southern California—it is given in full.

"The year 1900 was very dry; only about eight inches of rain (I think). The usual rainfall is sixteen. In the winter of 1900–1901 we had twenty-three inches."

Sierra Madre, 1,700 feet above sea level, twelve miles northeast of Los Angeles, at the base of the foothills, has a climate considered particularly healthful, and was the location selected by the State Board of Health in 1880 as the one most favorable for consumptives in Southern California.

There are various other places in the sheltered San Gabriel Valley favorable for invalids suffering from tuberculous, renal, or cardiac affections. Such are San Gabriel, Monrovia, Duarte, and others.

Echo Mountain, 3,500 feet high; Mount Lowe, 5,650 feet; Mount Wilson, 5,400 feet, all easily reached from

Los Angeles or Pasadena, command wide and extensive views. Hotels are found on the summits of these mountains, and the climate, besides possessing the characteristics of that of Southern California, has also the peculiarities of altitude. *Edward O. Otis.*

LOSOPHAN.—(Tri-iodo-meta-cresylic acid.) An antiseptic preparation, obtained by the action of iodine upon oxytoluic acid in the presence of an alkali. Its formula is $C_6HI_3OHCH_3$, and it is said to contain eighty per cent. of iodine. It forms in white needles, insoluble in water, slightly soluble in alcohol, and readily soluble in ether, benzene, and chloroform. At 140° F. it is freely soluble in fatty oils.

It is particularly recommended in parasitic skin affections. It may be used in tinea tonsurans, scabies, pityriasis versicolor, also in prurigo, in chronic eczema, acne, and sycosis. It is contraindicated in all acute inflammatory conditions of the skin, as it is liable to increase the irritation and intensify the disease. The remedy may be applied in a solution of the strength of one per cent., or in an ointment of one to three per cent.

Beaumont Small.

LOUISVILLE ARTESIAN WELL.—Jefferson County, Kentucky.

Location.—On the corner of Tenth and Rowan streets, Louisville.

This well is 2,086 feet deep by 3½ feet in diameter, and occupied sixteen months in boring. The temperature of the water, as it issues from the orifice of the well, is 76.5° F. A self-registering thermometer sunk to the bottom of the well indicated 86.5° F. The point of constant temperature immediately beneath the surface at Louisville is 53° F. This result shows an increase of temperature of one degree for every sixty-seven feet until the bottom is reached. The following analysis was made by Dr. J. Lawrence Smith:

ONE UNITED STATES GALLON CONTAINS:

Solids.	Grains.
Sodium chloride	621.52
Calcium chloride	65.72
Magnesium chloride	14.77
Potassium chloride	4.22
Aluminum chloride	1.21
Lithium chloride	.10
Sodium sulphate	72.29
Calcium sulphate	29.43
Magnesium sulphate	77.33
Aluminum sulphate	1.80
Potassium sulphate	3.22
Sodium bicarbonate	2.72
Calcium bicarbonate	5.99
Magnesium bicarbonate	2.75
Iron bicarbonate	.35
Sodium phosphate	1.54
Magnesium iodide	.35
Magnesium bromide	.46
Silica	.88
Organic matter	.70
Loss in analysis	8.12
Total	915.47
Gases.	Cu. in.
Sulphureted hydrogen	2.00
Carbonic acid	6.17
Nitrogen	1.36

The water is quite similar to that of the Kissingen Springs in Bavaria, and to the Kentucky Blue Lick Springs. It has been found very beneficial in cases of dyspepsia and constipation and in functional liver complaints. *James K. Crook.*

LOUISVILLE MINERAL SPRINGS.—Pottawatomie County, Kan.

POST-OFFICE.—Louisville.

Accommodations in two hotels and in private families.

ACCESS.—Viâ Union Pacific Railroad to Wamego, thence three miles to spring by stage.

This resort has recently attracted much attention in Kansas. The springs are charmingly located in a natural blue-grass park of ten acres, which has been greatly improved. It is said to be one of the finest camping places in Kansas. The surrounding country is hilly and the location of the springs is about 900 feet above the sea level. The temperature ranges from 10° F. in winter to 100° F. in summer, these figures representing the extremes. The springs are two in number, and afford an abundance of pure, crystal water, having a temperature of 60° F. A qualitative analysis, made in 1885, showed the presence of iron, sulphur, soda, magnesia, and carbonic-acid gas. The waters have been found of great efficacy in constipation, dyspepsia, general debility, and liver and kidney affections. *James K. Crook.*

LOVAGE ROOT.—LEVISTICUM. The root of *Levisticum Levisticum* (L.) Lyons. This is a large, aromatic, yellow-flowered perennial herb, with a short, thick, fleshy rootstock, from which several large, simple roots are given off below, and three or four stout, upright, slightly branching stems above. All parts of the plant have a strong and rather agreeable fragrance, due to its peculiar essential oil, and the root contains also considerable resin. When fresh, the stem and leaves exude a yellowish latex upon being broken.

Lovage is said to be truly wild only in Southeastern Europe (Bosnia and Servia, Flückiger), but it has been cultivated for centuries in other parts of Europe, and is extensively naturalized. That of commerce comes principally from Holland, Germany, and France. It is at present cultivated upon a small scale in the United States. The "root" is most in demand, although the fruit has more oil. It consists of the rhizome split or quartered, and, more abundantly, of the roots themselves, either whole or split. The pieces are of a brown, gray-brown, or black color externally, transversely marked near the top, elsewhere deeply longitudinally wrinkled and shrivelled; section white, yellow, or reddish; resin canals visible; texture spongy and flexible. Odor and taste peculiar, aromatic, resinous, bitterish-sweet, angelica-like. It is very prone to being worm-eaten, and an article entirely free from this defect is difficult to obtain. *Essential oil*, *resin* (yielding umbelliferon), *malic* and *angelic acids*, *gum* and *sugar* are among its constituents; to the first two it owes its medicinal value, whatever that may be.

It is a rather pleasant stimulant, aromatic, and diuretic, of the angelica and musk-root kind, with no active properties. It is sometimes given as a diuretic in dropsies from heart disease, etc., also for catarrh of the bladder, and for chronic bronchitis. It is, however, little used in this country, and even abroad has degenerated mostly to the level of a household herb among the country people.

Oil of lovage is an article of commerce, existing in three forms—from the root, from the fruit, and from the fresh herb. Although differing in specific gravity and slightly in flavor, they are very similar. *W. P. Bolles.*

LOWER BLUE LICK SPRINGS.—Nicholas County, Kentucky.

ACCESS.—Viâ Kentucky Central Railroad to Carlisle, thence nine miles by stage to springs.

We have not been able to obtain any recent information in regard to the condition of this resort. The following analysis of the main spring was made by Dr. Robert Peter, the State geologist, a number of years ago:

ONE UNITED STATES GALLON CONTAINS:

Solids.	Grains.
Magnesium carbonate	1.36
Calcium carbonate	23.65
Potassium chloride	1.39
Sodium chloride	512.85
Magnesium chloride	32.39
Potassium sulphate	8.93
Calcium sulphate	33.99
Magnesium iodide	.05
Magnesium bromide	.24
Alumina, lime, phosphate, iron oxide	.36
Silicic acid	1.10
Loss	17.72
Total	634.03
Gases.	Cu. in.
Carbonic acid gas	98.80
Sulphureted hydrogen	18.24

According to Walton these are exceptionally fine waters of the saline-sulphureted class, valuable in engorgements of the liver and abdominal viscera and diseases arising therefrom. They may be relied on in gastric catarrh, and in the form of warm baths they prove efficacious in diseases of the skin. Besides the main spring there are others on the opposite side of the Licking River and in its bed, which have been found on examination to be of a similar character. *James K. Crook.*

LUMBAGO.—See *Neuralgia.*

LUMBAR PUNCTURE.—See *Brain: Cerebro-Spinal Fluid,* and *Labor, Normal.*

LUNGS, ANATOMY OF THE.—Since the first edition of this HANDBOOK was issued many advances have been made in our knowledge of the anatomy of the lung. At the present time it seems to be one of the organs to which renewed attention has been directed.

In the present article questions bearing on the comparative anatomy of the lung have been omitted, and the reader is referred to the first edition of this HANDBOOK, Vol. IX., and to a paper, by the author of this article, in Vol. VIII. of the *Journal of Morphology,* for a discussion of this part of the subject.

HISTORICAL.—The first account we find of the structure of the lungs is the very incomplete one given by Hippocrates.[31] He compares them to a sponge interspaced with numerous small vessels. Aristotle[5] also gave to the lungs a spongy nature; the canals receiving blood from the so-called great vein. Celsus[15] also describes the lungs as being spongy. Galen[22] had only a little better idea of their structure; he describes them as being made up of lobes, liver-like in substance, and containing many vessels. Vesalius[68] describes the lungs as being divided into lobes, and says in regard to their structure that "the substance of the lung is soft, spongy, thin, light, airy flesh, as if formed of frothy blood, or bloody froth, and crowded with many branches of vessels."

We now come to the time when Harvey[25] announced his discovery of the circulation of the blood; this had its effect on all anatomical research. Malpighi,[46] profiting by this discovery, proved by means of injections that the air and blood were not contained in the same channels, but had separate systems of vessels, and that these did not communicate with each other, but did communicate among themselves. He also saw the circulation of the blood in the vessels of the lung of a living frog. He recognized the presence of air vesicles, and described them as opening into the trachea and communicating with one another. He also compares the lung to a sponge. Bartholin[7] defended the views of Malpighi. The next writer of note is Willis.[71] He is wrongly quoted by Williams,[70] who placed Willis among those who describe the air vesicles as communicating with one another. What he does say, directly opposite to the views of Malpighi, is that the bronchial tubes give off numerous small branches which bear on their distal extremity little bladders, thus giving the lung the appearance of a bunch of grapes. Helvetius[28] returned to the older idea and maintained that the lung was spongy in its nature. He denied that the spongy tissue of the lung was formed by the expansion of the bronchial tube, but asserted that the bronchus simply penetrated into the spongy tissue. His description is not very clear. Soemmering[66] describes the lungs as made up of small, irregular, polygonal cells grouped together into lobules. The individual cells of the lobule communicate, one with another, but those of one lobule do not communicate with those of adjoining lobules.

Early in the present century, Reisseisen[55] published a very important brochure in which he advanced views quite opposite to those accepted by the anatomists of his day. His method consisted in pouring mercury into a bronchus and, by applying gentle pressure, forcing it on until it appeared beneath the pleura. He describes the bronchi as dividing into branches which in turn divide quite rapidly, becoming at the same time much smaller, until eventually each small branch ends in a single rounded extremity. This was apparently a revival of the theory of Willis. Magendie[44] wrote two important papers on the lungs. In the first he denies that the bronchi terminate in air vesicles, but affirms that the air-cells of one lobule communicate with one another, but do not communicate with those of adjoining lobules. In his second paper he states that those grape-like structures described as hanging on to the end of a bronchus do not exist in nature, but are to be found only in books. His conclusion is that the lung is made up of "spongy tissue formed by the arrangement of the vessels, which have between them small spaces into which the air penetrates freely."

In 1832 Bazin[8] wrote supporting the views of Reisseisen, and was followed a few years later by Lereboullet,[42] who, in quite a lengthy essay, also supported Reisseisen. Addison[1] failed to find "any tubes ending in culs-de-sac; on the contrary, I always saw air-cells communicating with one another in every section I made." He describes the bronchi as dividing, within the lobule, into numerous minute branches which terminate in "branched air-passages and freely communicating air-cells. Huschke,[34] however, writing about the same time, described the bronchi as ending in fine branches, which bore on their free extremity small sacs which did not communicate with one another.

Rainey[54] wrote several excellent memoirs on the lung. He says "they are made up of bronchial tubes, bronchial intercellular passages, and air-cells." These air-cells communicated with one another and with the bronchi or bronchial intercellular passages, by means of large circular openings. Moleschott[51] published an excellent brochure in which he combats strongly the opinion of those who hold to the communication of one vesicle with another. In no instance did he find the bronchi forming anastomoses; he also distinctly states that the air-vesicle contains no opening except that by which it communicates with its proper bronchial tube.

Rossignol[60] gave us a very valuable treatise on the structure of the lungs. He introduced the term "infundibulum." According to this author the bronchi give off numerous branches, which cross each other repeatedly in all directions, but do not communicate; from the ultimate division of the bronchial tube arises a dilatation in the form of a funnel, which he terms "infundibulum." The walls of each infundibulum are lined with numerous air-cells or alveoli. Rossignol compares each infundibulum with its alveoli to the lung of the Batrachians, and says: "The lung looked at from this point of view can be defined as the assemblage or concentration of innumerable small lungs, held together by means of a common bronchial tree." In an inaugural dissertation written by Adriani,[2] he adopts the nomenclature of Rossignol. He also describes alveoli as existing on the walls of the bronchial tubes just before they dilate into infundibula. He takes strong exception to Rossignol's statement that there are no communications between adjoining alveoli, declaring it to be without doubt false, and describes minute openings by which adjoining alveoli communicate.

Kölliker[39] gives quite a valuable description of the finer structure of the air-passages. He considers the term "infundibulum" introduced by Rossignol unnecessary, and says that "all the vesicles belonging to one lobule open, not into ramifications of the finest bronchial twig going to it, but into a common space from which the air-vessel is afterward developed."

The "Cyclopædia of Anatomy and Physiology"[70] contains an article on "Respiration" by Williams, in which he has embodied some of his personal investigations. He describes each lobule as being sacculated and receiving a single bronchial tube; this tube gives rise within the lobule to small branches which subdivide to the third or fourth order, and from these latter branches the air-cells arise. He discards the term "infundibulum," and uses in its place that introduced by Rainey, "intercellular passage." Mandl[47] describes the bronchial tubes as ending in terminal cavities which have numerous depressions

in their walls, the "vesicles." He compares the terminal cavities and their vesicles to the lung of the frog.

In 1860 Waters[69] published a most excellent essay on "The Human Lung," in which he describes the "ultimate

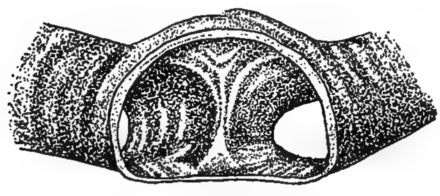

FIG. 3232.—View from above of the Division of the Trachea. The lumen of the trachea is divided by a ridge which extends sagitally somewhat to the left of the mid-line. Above is seen a broad, triangular space, the "anterior spur triangle," and below is seen the smaller "posterior spur triangle." To the right of the carina the opening of the large oblique right bronchus is seen; to the left of the carina the opening of the more horizontal left bronchus is just discernible. (After Heller and von Schrötter.[27])

pulmonary tissue" as being made up of elongated air-sacs arranged in groups, called by him "lobulettes," which spring from the enlarged end of a terminal bronchial twig; the air-sacs bear on their sides and ends depressions varying in number, the alveoli. He failed to find any communication between the air-sacs. On this point he says: "I have never found, either in the lungs of man, or of the dog, or cat, or pig, or sheep, or of any other mammal I have examined, any lateral orifice of communication between the different sacs of each lobulette."

Schulze[63] has given us an exceedingly interesting study of the lung which contains much that is of especial value. I shall refer more in detail to his work in another part of this article.

Henle,[29] in his systematic work on anatomy, gives a very good article on the lungs. He describes communications between air-cells, but considers them anomalies. He found them in the lungs of old people, and attributed them to the result of atrophy and absorption of the lung substance. Delafield[18] advocates the theory of communication between air-cells. He says: "The air-passages seem to be made up of a succession of large vesicles which open into each other, or of an irregular larger canal made up of vesicles into which other vesicles open from all sides." He also describes anastomoses between the air-passages. Roosevelt[59] agrees with Delafield in regard to the communication of the air-cells.

Miller[49] has contributed several papers on the structure of the lung dealing with the subject from the standpoint of the comparative anatomist and also from that of the histologist.

Besides the authors mentioned above, the reader is referred to the published work of Milne-Edwards,[50] His,[32] Ewart,[21] Narath,[52] d'Hardiviller,[24] Huntington,[33] Arnold,[6] and Birch-Hirschfeld.[12] Other authors who have made special studies in the histology of the lung will be referred to under the proper heading.

TRACHEA.—For the general structure of the trachea I will refer the reader to the text-books on anatomy, mentioning especially Quain.

As the result of numerous studies carried on in the Anatomical Laboratory of the University of Wisconsin it has been found that the submucosa proper of the trachea contains a much larger number of elastic fibres than is usually described as being present. These fibres are quite fine and arise from the dense network of the longitudinal layer of elastic fibres and pass toward the epithelium. Their course is irregular and they form a wide-meshed network of fibres. When they reach the outer border of the submucosa, just beneath the epithelium, they change their course and run parallel to the longitudinal layer.

In 1896 Heller and von Schrötter[27] published the results of their investigations on a series of human tracheæ, together with quite a complete historical review of the work previously accomplished. The object of their research was to find if possible some general plan on which the *carina tracheæ* is formed. They were, early in their investigations, greatly impressed by the inconsistency of the anatomical conception of the carina, and it appears that the farther they went in their investigations the more variations they found, and that no definite rule could be formulated.

Their series consisted of one hundred and twenty-five human tracheæ and forty-eight taken from various mammals. In the majority of cases the entire trachea with bronchi attached was used, but in some instances only the lower part of the trachea and attached bronchi could be obtained.

Their results may be summed up as follows: If the trachea is cut off about 2 cm. above its division an exact view of the place of bifurcation is afforded. One sees (Fig. 3232), looking at such a preparation from above, a nearly sagittally arranged larger or smaller ridge dividing the lumen of the trachea. The walls of this ridge enlarge toward the anterior wall of the trachea into a more or less triangular surface which is designated as the "anterior spur triangle"; toward the posterior wall the edges of the ridge diverge less, and there thus arises a small triangular surface of more or less inclination, called the "posterior spur triangle." The middle part of the spur connects these two surfaces with each other.

In the majority of cases the *carina* possesses a cartilaginous foundation. In the ridge which projects more or less into the lumen of the trachea, and inclined abruptly or gradually toward the inner wall of the bronchi, one or more cartilaginous plates are embedded which bear at the same time the crest of the *carina*. The cartilages correspond in direction to the crest, passing from in front backward, with a greater or less downward curvature to enter the ligamentous posterior wall. In those cases in which one or more cartilaginous plates entered into the dividing line or were actually embedded in the ridge, the spur was designated as "cartilaginous spur," in contradistinction to those cases in which cartilaginous crescents, usually the first bronchial, appear near the dividing ridge but do not actually enter it. The cartilage acts in these cases as lateral supports to the *carina*, and a transsection taken through its centre shows that the part corresponding to the angle of division, as well as the ridge projecting into the lumen of the trachea, is a membranous de-

FIG. 3233.—Types of the Carina Tracheæ. View from behind. The cartilages are represented by solid black bands. *A*, Tracheal; *B*, bronchial-right; *C*, bronchial-left; *D*, membranous. (After Heller and von Schrötter.[27])

velopment. In these cases the spur is designated as "membranous spur" (Fig. 3233, *D*).

It must, however, be conceded that in many cases these distinctions are difficult to follow, since combinations can be made by means of many different cartilaginous formations, *e.g.*, the anterior part of the spur is frequently membranous while the posterior part may be formed by the coming together of two cartilaginous plates from the right and left sides, respectively.

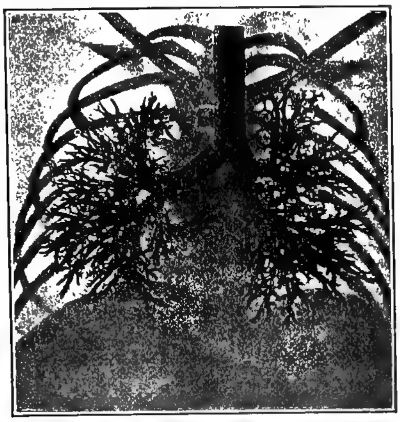

FIG. 3234.—A Röntgen-Ray Photograph of the Trachea and Bronchi Injected with Wood's Metal *in situ*. The very oblique direction of the right and the horizontal direction of the left bronchus are clearly shown. View from behind. (After Birch-Hirschfeld.[12])

In a large number of tracheæ the spur is formed in the following manner, as Luschka[43] had previously pointed out: the last tracheal ring is wider and thicker in its middle portion or is provided on its lower border with a longer or shorter process which enters into the bifurcation, while the first right and left bronchial rings converge downward and backward at an acute angle toward each other, meeting or fusing with one another. By means of this twisting, their anterior surface gradually passes from the frontal line into the sagittal line. Moreover, it may happen that the cartilage undergoes various modifications, *e.g.*, it may have thick or thin places or it may have sharp or blunt ends.

In those cases in which the dividing ridge is formed by the bronchial rings, the spur is called "bronchial spur"; and accordingly as only the first right or left bronchial rings enter into the formation of the spur it is designated "bronchial-right" (Fig. 3233, *B*) or "bronchial-left" (Fig. 3233, *C*). In some cases the first bronchial rings on both sides enter the spur; in that case it is "double bronchial."

In the majority of the tracheæ studied by Heller and von Schrötter it is the plate of cartilage corresponding to the last tracheal ring, or a cartilaginous process of the last tracheal ring, which enters into the spur. In these cases the spur was designated as "cartilaginous tracheal" (Fig. 3233, *A*).

It was often difficult to determine whether bronchial cartilages or tracheal cartilages entered into the formation of the spur. The usual distinction of a spur as bronchial or tracheal was to recognize whether the respective cartilage rings lay above or below the outer angle which corresponds to the division of the bronchi.

Out of the 125 human tracheæ investigated by Heller and von Schrötter the spur was found to be cartilaginous in 56 per cent.; membranous in 33 per cent.; partly membranous and partly cartilaginous in 11 per cent.; in 27 per cent. where the spur was cartilaginous, it was tracheal; in 21 per cent. it was bronchial, divided as follows: 15 per cent. bronchial-right, 3 per cent. bronchial-left, and 3.5 per cent. double bronchial.

In 92 cases the sex was observed. In 60 cases the spur was cartilaginous, 33 being in males and 27 in females. In 32 cases the spur was membranous, 15 being in males and 17 in females. Although, according to this, the occurrence of the cartilaginous spur appears to be slightly more frequent in males than in females, yet the formation of the carina as regards sex variation cannot be considered of any great importance compared to the size of the lumen of the trachea of the male in contrast to that of the female.

Heller and von Schrötter studied among other mammalian *carinæ* those of three cats, finding two of the three to be membranous and one cartilaginous. The number studied was entirely too inadequate, as studies in the Anatomical Laboratory of the University of Wisconsin have shown. In this investigation the *carinæ* of 50 cats were examined and the results were as follows: In 16 the spur was tracheal = 32 per cent.; in 5, bronchial-right = 10 per cent.; in 6, bronchial-left = 12 per cent.; in 10, double bronchial = 20 per cent.; in 3, membranous = 0.06 per cent.; in 10, tracheo-bronchial = 20 per cent.

An interesting fact in this connection is that if cases 12 to 16 inclusive had been the only ones studied, the result would have been three membraneous spurs and two cartilaginous. It is highly probable that if as extended a study were made in other mammals used by Heller and von Schrötter, the cartilaginous type, and not the membranous, as was found by them, would be found to be the rule.

BRONCHI.—The trachea divides into the right and left bronchus at about the level of the fourth thoracic vertebra. According to Bianchi and Cocchi[11] this division seldom takes place lower than the upper part of the fifth thoracic vertebra.

Of these two bronchi the right is the shorter and wider and is usually described as having a more horizontal direction than the left. Pansch in 1884, followed by Jössel in 1889, began to advance the opposite view, and Aeby[3] in his admirable monograph showed conclusively that the right bronchus is the more oblique. Schrötter[62] also expressed wonderment at the constantly repeated error. Fig. 3234, taken from Birch-Hirschfeld,[12] shows a Röntgen-ray photograph of an injection of Wood's metal into the trachea and bronchi *in situ*, and brings out clearly the more horizontal position of the left bronchus.

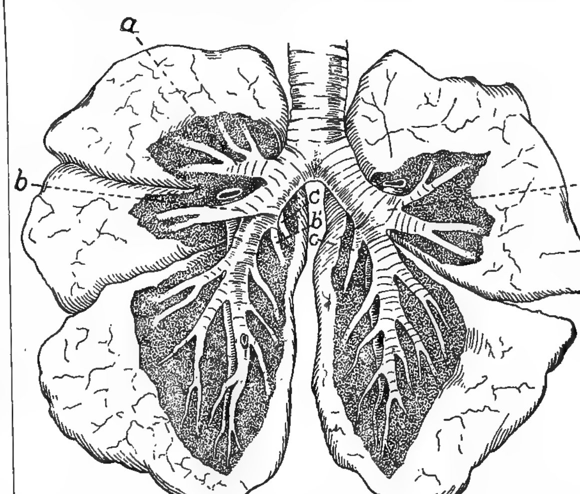

FIG. 3235.—Lung and Bronchial Tree of Man. *a*, Eparterial bronchus; *b*, first ventral hyparterial bronchus; *b'*, cardiac bronchus; *c*, first dorsal hyparterial bronchus. The cut ends of the pulmonary artery can be seen just above the first ventral hyparterial bronchi. (After Aeby.[3])

If the fact be taken into account that the *carina* is situated to the left of the centre of the lumen of the trachea (Fig. 3232), and that the right bronchus is the larger[14] and the more oblique,[37] it is easily seen (Fig. 3234) why for-

eign bodies pass so readily into the right bronchus and lung.

Aeby[3] demonstrated that there is a main bronchus (Stammbronchus), gradually diminishing in size, which extends through each lung. These main bronchi are direct continuations of the two bronchi into which the

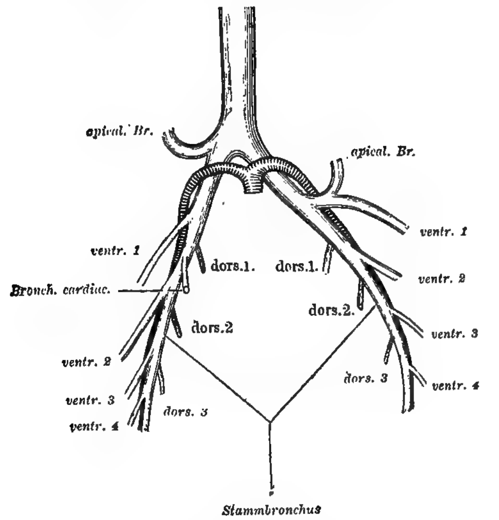

FIG. 3236.—Scheme of the Bronchial Tree. *apical. Br.*, Apical bronchus = eparterial bronchus of Aeby; *ventr. 1, 2, 3, 4*, ventral branches; *dors. 1, 2, 3, 4*, dorsal branches of the main bronchus (Stammbronchus); *Bronch. cardiac*, cardiac bronchus. The pulmonary artery is indicated by the shaded vessel. (From Merkel, after Narath.[52])

trachea divides. From each main bronchus lateral branches are given off in a monopodial manner; these lateral branches were named by Aeby dorsal and ventral bronchi. The dorsal bronchi are usually shorter and slenderer than the ventral bronchi (Fig. 3235).

According to Aeby the pulmonary artery, as it passes to each lung, crosses the main bronchus near its upper part and, running along its lateral side, gradually comes to lie dorsal to the bronchus (Fig. 3235). All lateral bronchi which arise from the main bronchus, below the place where the pulmonary artery crosses, were called by Aeby hyparterial bronchi. On the right side in man a single, rather large bronchus arises from the main bronchus, above the place where the pulmonary artery crosses, and was called by Aeby the eparterial bronchus (Fig. 3235, *a*).

Occasionally in man the eparterial bronchus arises directly from the trachea; this point of origin is constant in sheep and in the ox. Some of the lower vertebrates have on the right side an accessory lobe, termed the azygos or cardiac lobe, which receives a bronchus that is given off from the right main bronchus near the place where the first dorsal bronchus arises (Fig. 3235, *b'*). Below the point where the pulmonary artery crosses the main bronchus the arrangement of the lateral bronchi is the same on each side. This peculiarity of the bronchi leads to the formation of three lobes for the right lung, but of only two for the left lung. Aeby reasons that as the eparterial bronchus is not present on the left side, the lobe to which it is distributed is absent, and that the upper lobe of the left lung and the middle lobe of the right lung are homologous.

This conception of Aeby, which he evolved from his studies of the comparative anatomy of the lungs, received confirmation from His, who studied the development of the lungs in human embryos of various ages. His[32] showed that from the first there was an unsymmetrical arrangement of the lung buds, there being three on the right side but only two on the left. His agreed with Aeby that the mode of branching for the main bronchus was monopodial, but disagreed as to the lateral bronchi, which he claimed were dichotomous in their mode of branching.

Ewart[21] in quite an extended brochure opposed the views of Aeby and attempted to establish a complicated nomenclature for the various divisions of the bronchi and blood-vessels. Ewart came to the conclusion "that all bronchi are dichotomous; and that in any bronchial pair the greater size of one bronchus is correlated with the greater mass of lung tissues which it must supply with air."

Narath[52] denies that the pulmonary artery influences the development of the bronchial tree. He claims that the eparterial bronchus on the right side is homologous with the dorsal branch arising from the first ventral bronchus on the left side. The eparterial bronchus, according to Narath, is therefore a dorsal lateral branch of the first ventral bronchus which has migrated up the main bronchus (Fig. 3236). In a later communication Narath[52, a] studied the problem from the embryological side and found confirmation of his previously expressed opinion.

As the result of a series of comparative anatomy studies Huntington[33] reaches the conclusion that "the right and left lungs agree, morphologically, in the type of their bronchial distribution." This leads to the following proposition:

Right side.		Left side.
Upper + middle lobe	=	Upper lobe.
Lower + cardiac lobe	=	Lower lobe.

Huntington agrees with Narath that migration and not the pulmonary artery is the active principle in modifying the architecture of the lung, but disagrees with Narath in the derivation of the apical bronchus. The type of bronchial division is given by Huntington as being "practically dichotomous."

In a number of contributions, of which only the first and last are given in the bibliography, d'Hardiviller[24] opposes the theory of dichotomy, supporting Aeby in this respect, but strongly opposes him in the manner in which the bronchi arise from the main stem. The lungs are at first symmetrical and have on each side an eparterial bronchus. Deviations from this type are to be referred to the result of atrophy. The eparterial bronchus is not a lateral branch of a hyparterial bronchus as described by Narath, but is a special bronchus.

Birch-Hirschfeld[12] has investigated the bronchial tree of adults and agrees with Narath that the upper part of the left lobe corresponds to that part of the right lung which is supplied by the "eparterial bronchus." From a pathological standpoint Birch-Hirschfeld thinks that only such branches should be designated "apical" as are exclusively distributed to the upper portion of each lung.

A recent study by Justesen[35] of the division of the bronchi leads him to the conclusion that the mode of division is a modified dichotomy in which one branch becomes much more highly developed than the other. This

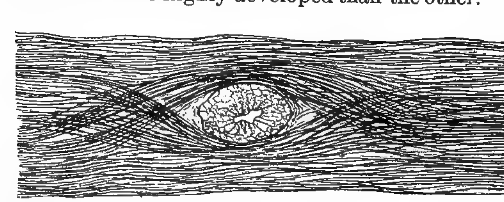

FIG. 3237.—Arrangement of Elastic Fibres in a Medium-sized Bronchiolus at the Place where the Duct of a Gland Opens into the Lumen of the Bronchiolus. Weigert's staining. (Miller.)

type of division is designated by Justesen "sympodial," a name applied by botanists to a similar mode of branching in plants.

At the hilus of the lung we find the artery, vein, and bronchus lying in quite close apposition. The arrangement differs on the two sides; on the right side the bronchus lies behind, the artery in the centre and the vein on

the outside, the bronchus occupying a higher level than the other two vessels. On the left side the vessels have the same order, but the artery occupies the higher place.

The bronchi, in their finer structure, have the same arrangement as the trachea up to their entrance into the lung. With the division of the bronchi within the lung we find changes in the structure. The cartilage which has been in the form of incomplete rings is now found in the form of angular plates, which are placed at longer and longer intervals, until at last it is found only as a small plate at the fork of the smaller branches. Bronchi which have a diameter of 1 mm. and under rarely have cartilaginous plates. At the same time that the cartilage begins to disappear, the smooth muscle which has been in the form of rings gradually spreads out into a uniform layer, which diminishes in thickness with the diminution in the calibre of the bronchus. Distal to the terminal bronchus smooth muscle is not found. In the larger bronchi the mucosa is arranged in longitudinal folds and consists of at least two layers, the innermost of which is made up of ciliated epithelium and goblet cells. In the smaller bronchi the ciliated epithelium is replaced by a single layer of non-ciliated columnar epithelium; in the terminal bronchi the epithelium gradually becomes cubical and finally passes over into the thin, flat "respiratory epithelium."

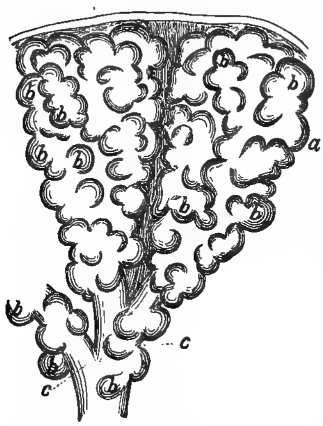

FIG. 3238.—Two Small Pulmonary Lobules. *a*, With the air-cells; *b*, *b*, and the finest bronchial twigs; *c*, *c*, which also possess air-cells. From a new-born child. Half schematic. (From Kölliker.[39])

The elastic fibres of the bronchi are arranged in a single layer in which the fibres run parallel. Where this layer is pierced by the ducts of the glands the fibres take a crossed arrangement, which gives additional strength to the otherwise weakened layer (Fig. 3237).

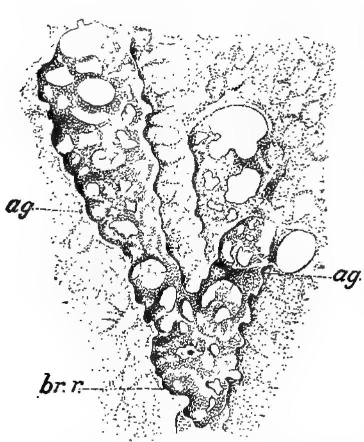

FIG. 3239.—Lung of a Dog. *br.r.*, Bronchiolus respiratorius; *ag*, two alveolar passages, one of which is continued into an infundibulum. (From Kölliker.[39,a]). This practically represents Fig. 3238 in section.

THE LOBULE.—The term lobule is used at the present time to describe two different areas in the lung. Following the majority of investigators, and because the author of this article believes it to be the correct usage of the term, the lobule of the lung may be defined as being composed of a terminal bronchus, the air spaces connected with it, and their blood-vessels, lymphatics, and nerves. This must be considered the unit of the lung.

Laguesse and d'Hardiviller[41] call those large areas, faintly marked out on the surface of the human lung, distinctly marked out on the lung of the ox, the lobules, and give the name acinus to the structures connected with a ductulus alveolaris (terminal bronchus). Councilman[16] thinks the unit should be called an acinus.

The author cannot agree with these statements. The acinus of a gland does not correspond to the lobule as here described; it might have been applied with some degree of justice to the conception of the lobule as described by Kölliker.[39] If any part of the lobule of the lung is to be compared to an acinus it is an atrium with its air sacs; but until "acinus" is used to describe a more definite portion of a gland than its present usage does, no intelligent comparison can be made.

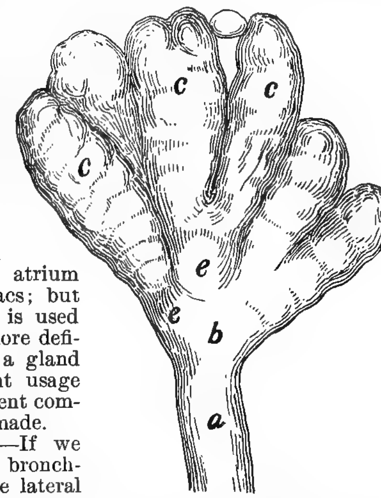

FIG. 3240.—An Ultimate Bronchial Tube with a Group of Air-Sacs, or Lobulette, connected with it (human). *a*, Ultimate bronchial tube; *b*, the dilated end of the same; *c*, *c*, single air-sacs; *e*, *e*, openings of other sacs which lie beneath those drawn; six air-sacs are seen which converge to a common centre. (After Waters.[69])

AIR SPACES.—If we follow the main bronchus or one of the lateral branches toward its distal extremity, we finally reach a point where the smooth tubular character of the bronchus disappears and we find small projections appearing on all portions of the bronchus. These projections (alveoli) were first described by Rossignol[60] and shortly afterward confirmed by Kölliker.[39] Alveoli are also present on the succeeding and final division of the bronchus (Fig. 3251).

Up to this point there is a general agreement of investigators, but they disagree in regard to the structure distal to the terminal bronchus. That this should be the case is not surprising, in view of the difficulties which attend the study of this part of the lung.

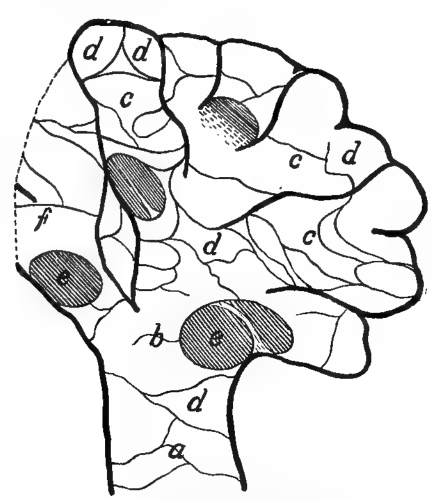

FIG. 3241.—Ultimate Bronchial Tube with its Air-Sacs (cat). *a*, Ultimate bronchial tube; *b*, its dilated end the *point de reunion* of all the air-sacs; *c*, *c*, *c*, air-sacs; *d*, *d*, alveoli; *e*, *e*, openings leading to other air-sacs; *f*, part of the wall of two air-sacs which are cut off. (After Waters.[69])

The most familiar description and diagram of the ending of the bronchi in the parenchyma of the lung is that

of Kölliker.[39] In his earlier work he rejects the very misleading term "infundibulum," introduced by Rossignol,[60] but in his later publication he returns to its use.[39, a]

He figures (Fig. 3238) the final division of the bronchus as ending in a single elongated cavity into which a vari-

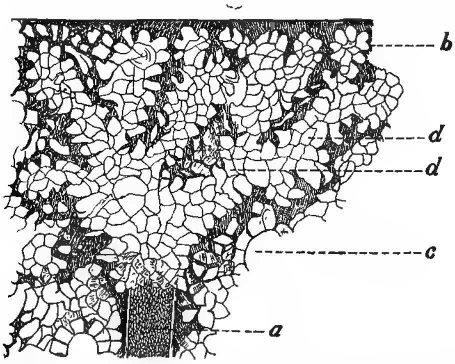

FIG. 3242.—Section of a Cat's Lung Filled and Hardened with Alcohol. *a*, Bronchiolus; *b*, infundibulum; *c*, transverse section of an alveolar passage; *d*, *d*, longitudinal section of an alveolar passage. (After Schulze.[63])

able number of alveoli open: these alveoli appear as elevations on the central cavity (infundibulum). The "alveolar passage" of his later publication has also numerous alveoli opening into it (Fig. 3239).

It is important to note one significant point in Kölliker's description of this alveolar passage, and that is the presence of smooth muscle. He says that it is easy to recognize smooth muscle in the walls of the alveolar passages;

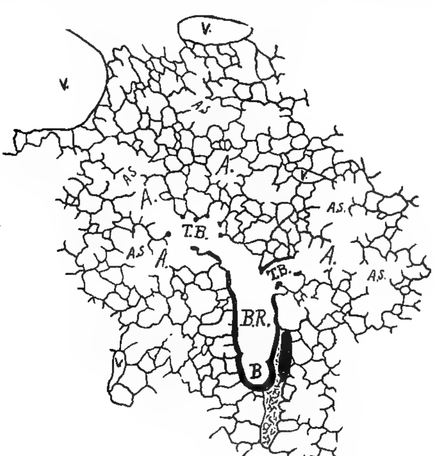

FIG. 3243.—Camera Lucida Tracing of a Section of a Cat's Lung. *B*, Bronchiolus; *B.R.*, bronchiolus respiratorius; *T.B.*, *T.B.*, ductuli alveolares (terminal bronchi); *A*, *A*, atria; *A.S.*, *A.S.*, sacculi alveolares (air-sacs); the remaining spaces are sections of sacculi and alveoli; *V*, *V*, pulmonary veins. Observe the relation which they bear to the lobule. The large vein at the left upper corner of the illustration is not completely outlined. The pulmonary artery is shown in solid black, cut obliquely, in the connective tissue beside the bronchiolus respiratorius. One of the atria is not directly connected with its ductulus alveolaris in this section, but in another section of the series the connection is shown. The heavy lines indicate the position of smooth muscle. (After Miller.[49, d])

that it generally has a circular arrangement around the alveolar passage, and that it forms a ring-like sphincter about the opening into each infundibulum. Kölliker found no smooth muscle in the walls of the alveoli or in those of the infundibulum.

The work of Waters[69] is not so well known to American readers as it deserves to be. He introduced the term "air-sac" in the place of the misnomer "infundibulum," and showed that a group of air-sacs communicate with each "ultimate bronchial tube" (Figs. 3240, 3241). Each air-sac communicates with the ultimate bronchial tube

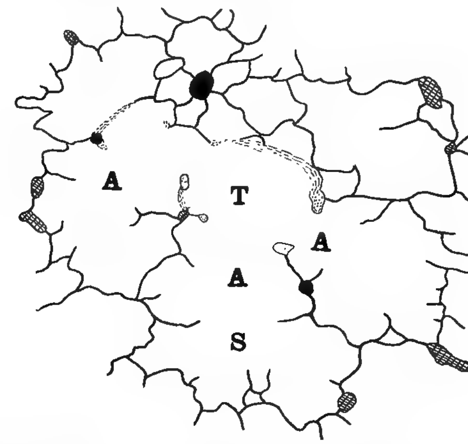

FIG. 3244.—Camera Lucida Tracing of a Section of a Dog's Lung. The plane of the section lies through the distal part of a ductulus alveolaris (*T*). Three atria (*A*) are shown and a number of sacculi alveolares (*S*). The pulmonary artery and two of its branches are shown in solid black; the pulmonary veins are shown checked. Note the small venous twig close to *T*; it is one of the small veins which corresponds to *2* in Fig. 3251. The broken lines indicate smooth muscle in longitudinal section; it is also seen in transverse section about the openings from the ductulus alveolaris into the atria. Two other atria not shown in this section belong to the lobule. (After Miller.[49])

by means of a circular orifice. More than one air-sac may terminate at one of these openings. The group of air-sacs which communicate with a given ultimate bronchial tube form a "lobulette." Some of the air-sacs bifurcate as they pass toward the periphery of the lobulette. Alveoli were present on air-sacs and ultimate bronchial tubes. Smooth muscle was present in the bronchial tubes but wholly absent in air-sacs and alveoli.

The diagram of Schulze resembles that of Waters, but his subdivision of the air-passages is different. Schulze[63] introduced the term "Alveolargang" for those air passages which are covered with alveoli and lead to the air-sacs (infundibula). The alveolar passage of Schulze is not the

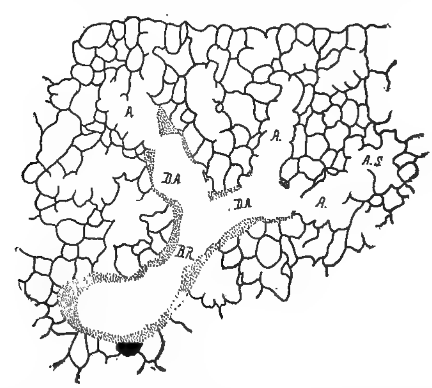

FIG. 3245.—Camera Lucida Tracing of a Section of the Lung of a Calf. The stippling indicates the nuclei of the epithelium and the position of smooth muscle. The section was a thick one and the plane was such that two ductuli alveolares (*DA*), connected on the one hand with the bronchiolus respiratorius (*BR*), on the other with the atria (*A*), were cut longitudinally; *A.S.*, sacculus alveolaris. The pulmonary artery is shown in solid black. (Miller.)

last division of the bronchus, but is the name given by him to all those air-passages which have alveoli (Fig. 3242). The alveolar passage of Schulze is, therefore, not identical with that of Kölliker, for it includes more than one division of the bronchial tree.

Lungs.

As the result of his investigations Miller[49] found that the last branch of the bronchus, which he calls the "terminal bronchus," before breaking up into the parenchyma of the lung becomes somewhat dilated at its distal extremity. Connected with this expansion of the terminal bronchus (Fig. 3251) there are from three to six nearly

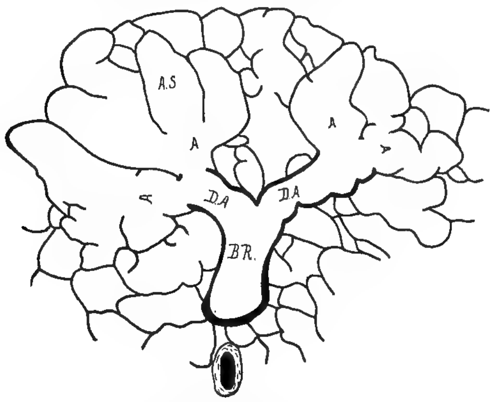

FIG. 3246.—Camera Lucida Tracing of a Section of the Lung of a Child Two and a Half-Months Old. Lettering as in Fig. 3245. The heavy black lines indicate the presence of smooth muscle. Pulmonary artery in solid black. (Miller.)

spherical cavities, the atria. Each atrium communicates, on the one hand, by means of a nearly circular opening, with the terminal bronchus; on the other hand, by similar-shaped openings, with a variable number of larger and more irregular-shaped cavities (air-sacs), which have small projections from their surface (alveoli, air-cells).

From this description it will be seen that the air-sacs do not communicate directly with the terminal bronchus,

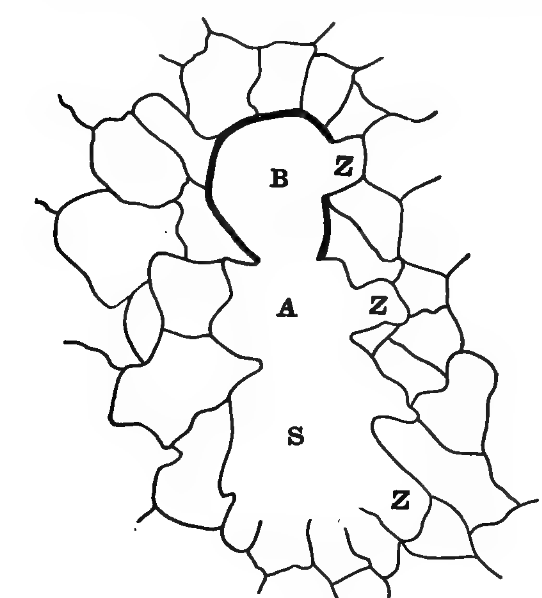

FIG. 3247.—Camera Lucida Tracing of a Section of the Lung of a Man Forty-three Years Old. *B*, Ductulus alveolaris; *A*, atrium; *S*, sacculus alveolaris; *Z*, *Z*, *Z*, alveoli. The plane of this section cuts the ductulus alveolaris transversely near its centre; smooth muscle is not present except in its walls. (Miller.)

as is usually described, but between each air-sac and terminal bronchus there is interposed a cavity, which is constant in all parts of the lung, viz., the atrium (Figs. 3243–3247)

The presence of the atrium has been confirmed by Justesen[35] in the lung of the ox; by Councilman,[16] who found it to be "the starting-point of most of the focal pneumonias of children;" and later, by Miller, whose investigations have shown its presence in the lung of the cat, dog, calf, child, and man (Figs. 3243–3247).

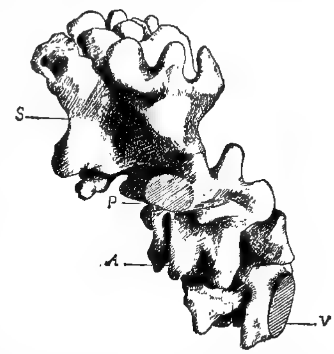

FIG. 3248.—Reconstruction in Wax of an Atrium (*A*) with a Single Sacculus Alveolaris (*S*) Attached. The surface *v* shows where the atrium was cut off from its ductulus alveolaris, and *p* shows where a second sacculus was cut off. The small projections from the atrium and sacculus are the alveoli. Five sacculi were connected with this atrium. (Miller.)

The atrium must not be confused with the alveolar passage of Kölliker or of Schulze. In each instance the alveolar passage contains smooth muscle, while it is absent from the walls of the atrium. The atrium is smaller than the air-sacs and, like the terminal bronchus and the air-sacs, has numerous air cells projecting from its surface. In structure the walls of the atrium resemble that of the air-sacs.

The structure of the terminal bronchus agrees with that of the alveolar passage of Kölliker and the distal portion of that of Schulze. It is tube-like and has a large number of air-cells opening into it. It possesses a very distinct layer of smooth muscle which forms a ring about the openings which lead into the atria, in the same manner as Kölliker described it to be present about the openings of his infundibula.

The epithelium of the terminal bronchus shows a transition from a low cubical type, in its proximal portion, to simple squamous epithelium (respiratory epithelium) in its distal portion. As Kölliker[39, a] pointed out, this transition is often quite irregular. Ciliated epithelium, goblet cells, and glands are absent in the terminal bronchi.

The form of the air-sacs is difficult to comprehend from the study of single sections because of their great irregularity both in size and in form. In the figures of Kölliker, Waters, and Schulze the air sacs (infundibula) are shown as having an elongated form. Luschka[43] states that the air-sacs just beneath the pleura are more rounded than those situated deeper in the lung. Miller[49, a] did not find this to be true. Fig. 3248 shows a reconstruction of the air-sac and atrium shown in section in Fig. 3244; the other air-sacs have been cut off from the atrium. Fig. 3249 shows a reconstruction of an air-sac which presents a deep incision, a feature that is quite frequent, as Waters[69] pointed out.

FIG. 3249.—A Reconstruction in Wax Showing a Single Sacculus Cut Off from its Atrium. The cut surface is easily made out in the figure. This sacculus has a deep septum extending a considerable distance into it, nearly dividing it into two separate parts. This sacculus presents a strong contrast to that shown in Fig. 3248. (Miller.)

It is very difficult to harmonize the descriptions of the various parts of the lung because no sharp boundary lines have been established. The different schemes of the lung and the nomenclature are also confusing.

Miller[49, d] has for the first time given a definite basis for comparison by bringing together in the following table the nomenclature used by the principal authors and

that of the "Nomenclatur-Commission an die Anatomische Gesellschaft" (B. N. A.).[13]

Miller.	B.N.A.	Schäfer.	Schulze.	Kölliker.
Bronchus III.	Bronchiolus respiratorius.	Bronchial tube.	Alveolargang.	Alveolargang.
Terminal bronchus.	Ductulus alveolaris.	Lobular bronchus.		
Atrium .... Air-sac....	....	Air-sac	Infundibulum	Infundibulum.
Air-cell	Alveolus pulmonis.	Air-cell	Alveole......	Alveole.

Recognizing that the B. N. A. is a decided advance in anatomical nomenclature Miller[49, d] recommends the discarding of all previous nomenclature, the retention of all names given under the heading "Pulmo" (B. N. A., p. 59) down to "Ductuli alveolares," and the insertion, then, of
"Atria"
"Sacculi alveolares."

The nomenclature would thus be made uniform and the objectionable term "infundibulum" would be discarded.

The finer division of the lung would then be:

B. N. A.	English.
Bronchioli.	
Bronchioli respiratorii.	
Ductuli alveolares.	Terminal bronchi.
Atria.	Atria.
Sacculi alveolares.	Air-sacs.
Alveoli pulmonis.	Air-cells.

The work of Hansemann[23] has added fresh interest to the question of open communications between the air-sacs. Kohn[38] called attention to the fact that in pneumonia fibres of fibrin could be traced from one alveolus into another through small openings in the walls of the alveoli. He did not consider these openings to be normal, but the result of the pathological process. The investigations of Ribbert,[58] Herbig,[30] Bezzola,[10] Aigner,[4] von Ebner,[19] and Miller[49] support him in this position. On the other hand, Hauser[26] and Hansemann[23, a] maintain that these openings are normal structures.

That these openings exist was known long before the announcement of Kohn. In the first edition of the Handbook (Vol. IX., p. 572) Miller called attention to the statement of Henle in the same words used in the present edition. "He (Henle) describes communications between air-cells, but considers them anomalies. He found them in the lungs of old people and attributed them to the results of atrophy and absorption of the lung tissue." The observation of Henle is correct. It is in the lungs of old individuals and animals that these so-called "pores" are best seen. In young individuals and animals they are not common. At birth, and until some unusual strain is put upon the lung, no pores are present.

The method used by Hansemann[23] to demonstrate these pores is very faulty, as Aigner[4] has pointed out. Moreover, but little importance should be placed on Hansemann's illustrations, because they merely show that a solution of gelatin containing a large quantity of water will easily filter through the walls of the alveoli under a low pressure.

The study of these so-called "pores" leads naturally to the consideration of the structure of the walls of the air-sacs. These are thin and contain the capillary network of blood-vessels, elastic fibres, and reticulum,[45] covered over by a layer of epithelium.

That the air-spaces are lined with a layer of epithelium every histologist now acknowledges, although the time is not so very distant when the presence of an epithelium was strenuously denied. At present the question is not in regard to the presence or absence of a pulmonary epithelium, but as to what are the shape, size, and arrangement of the epithelium; what is its relation to the structures it covers; is it, after all, a continuous epithelium? It will be impossible to answer these questions in the present article.

Elenz[20] says that in all mammals investigated by him the epithelium of the lung consisted of small cells in the form of "cell islands and large, membrane-like irregular plates." Kölliker[39, a] also describes the epithelium as consisting "of two types—a small, nucleated, flat, polygonal, protoplasmic cell from 7 to 15 μ in diameter, which is situated in the mesh of the capillaries, and large, irregular-shaped, generally nucleated, quite thin plates from 22 to 45 μ in diameter, which lie over the blood-vessels, but can also extend into their mesh."

Elenz[20] attached much importance to the clusters of small cells which he called "islands," and he described them as small, round, nucleated cells having a granular appearance; from one to fourteen cells were found in each island.

This holds true for very young animals, but in old animals they usually occur as single cells. In young kittens, for example, from six to twelve cells form a group, while in older animals the number is less (Fig. 3250). By actual count of a large number of equal areas in the lung of kittens and that of old cats the ratio was found to be five to three, showing a lessening of nearly one-half in the old cats.

In kittens the groups of small cells were quite uniformly distributed throughout the alveoli, while in old cats they were absent from the bottom of the alveoli, being found for the most part along the edges where the alveoli open into the air-sacs.

In studying the epithelium of the air-sacs in connection with the question whether "pores" are normal structures, it was found by Miller that in young kittens, for some length of time after birth, no openings (pores) could be found; when they were found in young cats they gave every appearance of having been caused by violence to the animal or by over-distention of the lung. In old cats they were more numerous, and were probably due to the concomitant changes of old age. The opinion already expressed is reiterated here, namely: "pores" are not to be considered normal structures.

The description of the epithelium given above is very superficial, and is by no means to be taken as the final solution of the problem.

Pulmonary Artery.—The pulmonary artery in its ramifications within the lung follows the subdivisions of the bronchi. At first the artery and bronchus have

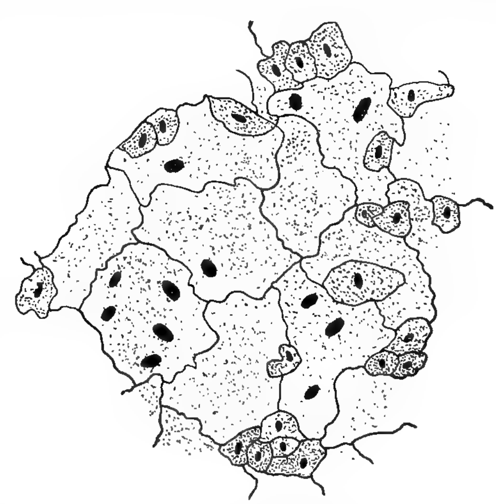

Fig. 3250.—Epithelium from an Alveolus of a Young Cat. The small granular cells and the large plates are shown. The significance of the scattered nuclei in the large plates has not been determined as yet. (Miller.)

nearly the same diameter, but the artery diminishes much more rapidly in size than the bronchus, so that by the time it reaches the lobule it is about one-fourth or one-fifth the size of the terminal bronchus. It is usually stated that the artery, as it approaches its ultimate ending, di-

vides much more frequently than the bronchus. This would hold true for the old conception of the lung.

It has already been pointed out how the terminal bronchus gives rise to the atria, the atria to the air-sacs, and that these collectively form the lobule. When the

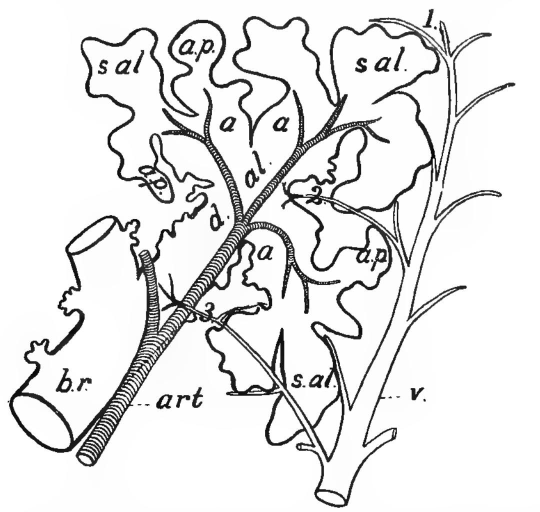

FIG. 3251.—Schematic Section of a Lobule of the Lung showing the Relation of the Blood-vessels to the Air Spaces. *b. r.*, Bronchiolus respiratorius; *d.al.*, ductulus alveolaris (the letters *al.* are in the widened distal end); a second ductulus alveolaris is shown cut off; *a, a, a*, atria; *s.al.*, *s.al.*, sacculi alveolares; *a.p.*, *a.p.*, alveoli pulmonis; *art.*, pulmonary artery with its branches to the atria and sacculi; *v*, pulmonary vein with its branches from the pleura (*1*), the ductulus alveolaris (*2*), and the place where the bronchiolus respiratorius divides into the two ductuli alveolares (*3*). (After Miller.[49, d])

artery reaches a point distal to the terminal bronchus it breaks up into as many branches as there are atria (Fig. 3251). Sometimes we find a special branch given off from the artery just before it enters the lobule which supplies the more dependent of the air-sacs (Fig. 3252). Each of the atrial arteries, after giving off twigs to the walls of its atrium, breaks up into small branches which run in the sulci between the air cells, are distributed to the central * side of the air sac, and end in a capillary network from which most of the pulmonary veins take their origin (Fig. 3251).

It is quite rare to find the pulmonary artery appearing on the periphery of a lobule or on the surface of the pleura. Anastomoses between branches of the pulmonary artery occur very exceptionally.

CAPILLARIES.—The capillaries into which the pulmonary artery breaks up form within the lung a very close network, the mesh of which, as Schulze[63] has pointed out, is exceedingly small, often less than the diameter of the capillaries that bound it.

From this capillary network venous radicles are formed which are situated on the opposite side of the air-sac from the artery. From the last point where the arterial radicles can be recognized to the first point where the venous radicles can be distinguished there are usually from twenty to twenty-five capillary loops.

This network of capillaries is situated within the walls of the air-sacs and, as already stated, forms a part of them. As Rainey[55] pointed out, only a single network is found in any given wall; the network is, therefore, common to two or more adjacent air-sacs.

Just beneath the pleura the mesh of the capillary network is much wider than that within the lung, the proportion being nearly four to one.

VEINS.—The veins are, with an exception to be noted later, always situated on the periphery of the lobule, while the arteries are within the lobule (Figs. 3251 and 3244).

* I use "central" to designate that part of the air-sac which is nearest to the centre of the lobule, "peripheral" for that which is most distal.

The pulmonary veins can be traced to three separate sources.

(*a*) The capillary network into which the pulmonary artery breaks up.

(*b*) The capillary network of the pleura.

(*c*) The capillary network in the walls of the bronchi.

(*b*) is in fact a subdivision of (*a*), but it is convenient to consider it separately, owing to its peculiar situation.

Veins Arising from the Capillary Network of the Pulmonary Artery.—The radicles of these veins arise from the capillary network just described and are situated on the peripheral side of the air-sacs. They do not run between the air-cells, as the arterial radicles do, but over the air-cells.* The greater part of the pulmonary veins have their origin from this network, and the trunks thus formed are found on the periphery of the lobule (Figs. 3244 and 3251).

Veins Arising from the Capillary Network of the Pleura.—Exceptionally, the pulmonary artery reaches the pleura; when this occurs it at once breaks up into capillaries which take part in the formation of the network to be described; usually, the pulmonary artery breaks up into capillaries before it reaches the pleura. These capillaries unite to form a wide-meshed network on the pleural side of the air-sacs and give rise to venous radicles. As a rule two, three, sometimes four, of these radicles unite to form a small vein just beneath the pleura, which at once passes along the periphery of a lobule to the deeper part of the lung, receiving on its way small veins which come from the air-sacs (Fig. 3251, 1). Anastomoses between the capillaries of the pleura are very numerous; consequently blood brought to the pleura by any given artery may be returned by several different veins.

This pleural network of capillaries has been described as being derived from the bronchial artery by Küttner,[40] Zuckerkandl,[14] and others. A careful study of the question, and of the illustrations of actual sections given by the author of this article in a previous publication (Miller[49, d]) will convince the reader, I feel certain, of the error of their statement.

Along the margins of the lung the radicles of the pulmonary veins are very distinct and superficial, and are often mistaken for other vessels.

Veins Arising from the Capillary Network in the Walls of the Bronchi. — The bronchial artery forms within the walls of the bronchi a network of blood-vessels, the mesh of which is elongated in the long axis of the bronchi. Wherever a branch is given off, be it from the main bronchus or from any of its branches, some of these capillaries unite on opposite sides of the bronchus to form small radicles, and these in turn unite to form a small vein, which immediately receives other radicles coming from the adjoining air-sacs. Two veins are thus

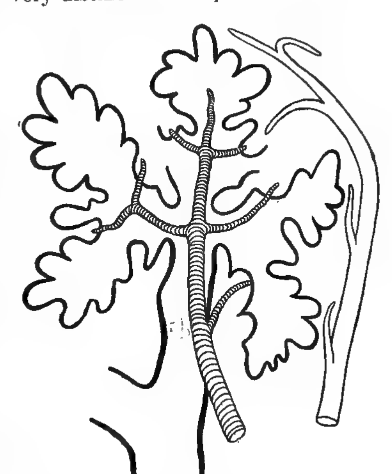

FIG. 3252.—Scheme of the Lobule of the Lung Cut at Right Angles to Fig. 3251. The artery is shaded; the vein on the periphery is in outline. The first scheme of the lung constructed by Miller. It shows the same arrangement of air spaces as in Fig. 3251, and also a small branch of the pulmonary artery that is frequently given off just as the artery enters the lobule. (After Miller.[49])

* See Journal of Morphology, vol. viii., pl. vii., Fig. 16.

formed, one on either side of the bronchus, which, running between the lobules, soon join one of the venous trunks (Fig. 3251, 3).

By the giving off of these venous radicles at each place where the bronchus divides, the bronchial network of capillaries becomes so diminished that when the ductuli alveolares (terminal bronchi) are reached it is reduced to a few capillaries, which at the distal end of each ductulus take part in the formation of two small veins in the same manner as those just described at the branching of the bronchi. The two small veins thus formed are the only ones found within the lobule; all others are on the periphery of the lobule. These also receive, on their way out, small branches from the adjoining air-sacs and eventually join one of the veins on the periphery of the lobule (Fig. 3251, 2). The bronchial vessels do not extend beyond the ductuli alveolares.

Zuckerkandl [74] has described blood-vessels arising from the bronchi, but their course is quite different from the above-described veins; and it is quite apparent he has mistaken the identity of some of the vessels which he describes.

In an article on "Lobar Pneumonia" Smith [65] advances some peculiar views in regard to the pulmonary circulation. He describes two sets of capillaries as being present in the septa between the air-sacs: one, the "functional capillaries," derived from the pulmonary artery; the other, the "nutritive vessels," derived from the bronchial artery.

That a very grave error is contained in the above statement every one who has made a study of the lung will recognize. It is difficult to understand how the error was made. A careful consideration of the preceding description of the blood-vessels will make the relation which they bear to the air-sacs and to each other clear, and show the fallacy of his statement.

Lymphatics.—Olof Rudbeck first described the lymphatics of the lung in 1651–54. He saw them on the lung of a dog and thought that they opened into the cavity of the heart. Willis [71] saw the superficial lymphatics of the lung of a calf and gave a very good illustration of them.

Mascagni [48] and Cruikshank [17] described two sets of lymphatics as being present in the lung—a superficial and a deep set, which communicated with each other. Both confine their description almost wholly to the superficial set, saying but little about the deep set.

Wywodzoff [73] studied the lymphatics of the lung of the dog and the horse. He described the lymphatics as arising from fine lymph capillaries situated in the walls of the air spaces. These lymph capillaries ran at an angle to the blood capillaries. He also described lymph spaces in the walls of the air-sacs in which lymph collected. The larger lymphatics were situated in the walls of the blood-vessels and bronchi; these two sets of deep lymphatics communicated with each other. The superficial lymphatics formed a network which was destitute of valves; only the deep set possessed valves. The two sets of lymphatics were connected with each other by branches which followed the course of the pulmonary vein from the pleura into the interior of the lung, where they joined other lymphatics coming from the bronchi or from other blood-vessels.

Sikorsky [64] described the lymphatics of the bronchi as originating from fine vessels situated between the ciliated epithelial cells lining the bronchi. These vessels united to form a network, which in turn gave rise to the main trunks which passed out of the lung at the hilus. In the walls of the air spaces a network of fine canals and lacunæ was found, which gave rise to a system of lymphatics which ran in the walls of the blood-vessels. In his second paper [64, a] he made no reference to his previous statements and evidently abandoned them. The pleural lymphatics he described as arising from the subpleural air spaces, and eventually formed trunks which passed to the hilus of the lung.

Sappey [61] does not favor the division of lymphatics into superficial and deep sets; for, he says, the two sets are in close communication everywhere. Each lobule of the lung is surrounded by lymph vessels, which are arranged in such a manner that they form a network between adjacent lobules in much the same manner as the blood capillaries do between adjacent air sacs.

Klein [36] divides the lymphatics into three sets:
(*a*) Lymphatics of the alveoli.
(*b*) Lymphatics of the bronchi.
(*c*) Lymphatics of the pleura.

Most of the lymphatics belonging to the first set accompany the branches of the pulmonary artery and vein. They arise from irregular spaces in the walls of the air sacs and are "provided with a special endothelial wall."

The lymphatics of the second set are found in the walls of the bronchi and communicate with the larger lymphatic trunks about the blood-vessels.

The third set are found in the pleura and connect with those of the first set on the one hand, and on the other with the pleural cavity by means of stomata.

von Wittich [72] found that if he allowed a solution of sulphindigotate of soda to drop slowly into the trachea of living animals and killed them after an interval of two hours, removing the lungs in the stage of deep expiration, a network of blue lines with here and there lacunæ similar to those described by Sikorsky [64] could be seen. The injection of a solution of silver nitrate, on the other hand, failed to demonstrate stigmata or stomata between the epithelial cells lining the air spaces, although the intercellular substance was well stained. He considered the network of blue lines which he obtained by the first method to be a coloration of the intercellular substance and referred the results obtained by Küttner [40, a] to the same cause.

Councilman [16] found a set of lymphatics accompanying the pulmonary artery, and a second set which was situated in the connective-tissue septa and joined the lymphatics of the pleura. Valves were found which opened toward the pleura. He failed to find any lymphatics about the veins. He considered that the second set of lymphatics "play an important part in the pathology of the lung, for it is undoubtedly by this route that infections in the centre of the lung extend to the pleura."

The latest investigations of the lymphatics are those of Miller. [49, c, d]

He classifies them as follows:
(*a*) Lymphatics of the bronchi.
(*b*) Lymphatics of the arteries.
(*c*) Lymphatics of the veins.
(*d*) Lymphatics of the pleura.

Lymphatics of the Bronchi.—In preparations in which the lymphatics have been successfully injected and occasionally in uninjected specimens a number of large-sized lymphatics can be seen coming from the hilus of each lung between the bronchus and blood-vessels. These lymphatics pass along the right and left bronchus to form a network on the posterior wall of the trachea and eventually become connected with a number of lymph nodes which are situated about the bifurcation. Valves are present in these vessels in large number and open toward the lymph nodes.

Within the lung the bronchial lymphatics have a different arrangement, depending on the presence or absence of cartilaginous rings. Where the rings are present there is a double network of lymphatics present which encloses the cartilage. That part of the lymphatic network which is situated just beneath the epithelium is composed of finer vessels, as Teichmann [67] pointed out many years ago.

In the finer rami bronchiales and bronchioli only a single plexus of lymphatics is present; the vessels of this plexus vary greatly in size and shape, and the mesh of the network which they form is elongated in the long axis of the bronchioli. In the terminal bronchi the lymphatics have been reduced to three small vessels which in transverse sections of the terminal bronchi are placed nearly equidistant from one another. Of these three lymphatics two pass to the small veins which arise at this place, while the third passes to the artery. Distal to the terminal bronchus no lymphatics are present.

This statement of Miller has been confirmed by Teichmann.[67, a]

Lymphatics also pass from the bronchial network to the veins which arise from the place where the bronchi divide and to the pulmonary artery. We have then, at the place where bronchi divide, the same arrangement as at the terminal bronchus, namely, two lymphatics passing to the veins and one to the artery. This emphasizes the fact that in order to comprehend the distribution of the lymphatics the arrangement of the blood-vessels must be fully understood (see Fig. 3251).

Fine lymphatics have been described by Sikorsky[64] as being found between the epithelial cells lining the bronchi and communicating on the one hand with the deeper lymphatics of the bronchi and on the other with the lumen of the bronchus. Sikorsky[64, a] in his later paper evidently abandoned the theory of open communication between the lymphatics and the bronchial cavity. A somewhat similar condition has been described by Klein under the name of "pseudo-stomata." Neither of these statements was confirmed by Miller.[49, d]

Wherever lymphatics unite triangular enlargements (lacunæ) are found. These lacunæ are especially well developed at the forking of the bronchi and seem to be associated with the small aggregations of lymphoid tissue found at this place by Arnold,[6] Klein,[36] and others.

Pigment, when present, is found along the lymphatics of the bronchi; at the forking of the bronchi it is associated with the lacunæ and lymphoid tissue found here, often completely obscuring them from view.

Valves are present in the lymphatics of the larger bronchi, but are absent in those of the finer divisions of the bronchial tree.

Lymphatics of the Arteries.—We have seen in the preceding account that the network of lymphatics in the walls of the bronchi gradually diminishes until in each terminal bronchus there remain only three small vessels, one of which joins the lymphatics about the artery.

Not only is there a communication between the bronchial and arterial lymphatics at the terminal bronchi, but there is also one at the place where branching of a bronchus takes place.

The larger branches of the pulmonary artery have as a rule two main lymphatics accompanying them. These are situated on opposite sides of the artery, and are so placed that one of them lies between it and the bronchus. The two main lymphatics are connected together by numerous loops, and in this way a long-meshed network is formed about each artery.

As the artery divides the lymphatics also divide, but the size of the lymphatics does not diminish so rapidly as that of the artery. When we come to the smaller arteries only a single lymphatic is found accompanying them. This generally runs parallel to the artery, between it and the bronchus.

Lymphatics of the Veins.—The two remaining lymphatics which arise from the terminal bronchus pass, one on either side, to the smaller veins which arise at this place, and have usually more of a spiral course than those about the artery. Lymphatics also pass from the bronchial network to the veins which arise at the place where the bronchi divide. We have, therefore, at the place where bronchi divide, the same relation of lymphatics to blood-vessels as at the terminal bronchi; that is, there are three lymphatics, one of which passes to the artery, the other two to the veins.

Finally, there are lymphatics which accompany those pulmonary veins which go to the pleura; these join the network of pleural lymphatics. There is always a well-marked lacuna at the junction of this vessel with the pleural network, and if pigment is present anywhere on the surface of the lung it is found about this lacuna.

The smaller veins, like the arteries, have but a single lymph vessel accompanying them, while the larger venous trunks have two, and often three, main lymphatics. These are connected together by numerous loops, and there is thus formed a network with a long mesh.

Pigment may be present about the lymph vessels accompanying the veins, but not so abundantly as about the arterial lymph vessels.

Wywodzoff,[73] Klein,[36] and other authors describe the lymphatics about the pulmonary artery and vein as having their origin in fine canals, which are situated in the walls of the air-sacs of the lung. In the study by Miller, already referred to, he shows that the appearances on which they based their conclusions, as shown in their illustrations, are artifacts, and says he has never found in the walls of the air-sacs anything which he could call a lymphatic or lymph capillary.

Lymphatics of the Pleura.—The lymphatics of the pleura are irregular in size and form a plexus which has no definite relation to the lobule of the lung (Fig. 3253). Many of these lymphatics are of quite large calibre, as Sappey[61] has pointed out. Sometimes these large lymphatics form an incomplete network in the mesh of which smaller lymphatics are situated, thus giving the appearance of a double network of lymphatics.

FIG. 3253.—Lymphatics of the Pleura. Note the irregularity of size and the numerous constrictions indicating the positions of valves. (After Miller.[49, d])

The lymphatics of the pleura have numerous valves (Fig. 3253), though Wywodzoff[73] says valves are present only in the deep lymphatics. The fact that there are so free anastomoses between the pleural lymphatics allows them to be easily filled with the injecting mass. While the presence of valves does not prevent the injection of the pleural lymphatics, they do prevent the injection of lymphatics within the lung from the pleura.

Pappenheim[53] has described two layers of lymphatics in the pleura of the horse. If his observation is correct, the condition is quite different from that in man. Klein,[36] as already observed, describes the pleural lymphatics as communicating with the pleural cavities by means of "true stomata."

Miller[49, c] denies the presence of stomata in the pulmonary pleura, and von Ebner[19] confirms his observation.

The ordinary method of attempting to inject the lymphatics by the very unscientific "puncture method" leads to many erroneous observations. Miller[49, d] gives a method by which they can be injected by inserting a specially devised cannula directly into one of the large lymph trunks. The reader is referred to the original paper for the details of the procedure.

NERVES.—At the present time our knowledge of the nerve distribution within the lung is very deficient. The main trunks which supply the lung come from the pneumogastric and sympathetic; these unite at the root of the lung and form the anterior and posterior pulmonary plexuses. The posterior plexus is the larger of the two. From these plexuses branches extend into the lung and are distributed along the bronchi and the pulmonary and bronchial blood-vessels. Along the course of those branches which accompany the bronchi Remak[56] found numerous small ganglia. Since the investigations of Remak the only important work on the nervous supply of the mammalian lung has been done by Retzius and Berkley. Retzius[57] found in the lung of a human embryo, 15 cm. long, which had been stained by Golgi's method, that he could follow the nerves as far as the last division of the bronchus; distal to that point he does not seem to have found any nerves.

Berkley[9] also used the silver method in his study. His results may be summed up as follows:

The main nerve supply to the lung tissue is derived from the nerves which accompany the bronchial arteries. Nerve fibres are frequently seen in the septa between the alveoli, in the central portion of the lung as well as near

the root of the lung. A direct ending of the nerves in the immediate neighborhood of the epithelium lining the air sacs was not found. The mucous membrane and muscular tissue of the bronchi are innervated from the nerves following the bronchial artery, and also from the very considerable plexus of nerve fibres found in fibrous layers about the bronchi. In the muscle the nerves end in small, rounded bulbs upon, and not within, the muscle cells. In the larger bronchi nerves could not be followed through the fibrous layer immediately under the epithelium, but in the smaller bronchi the nerves could be followed to a well-marked interepithelial arborization. The nerve supply of the pulmonary blood-vessels is not so large as that to the bronchial.

William Snow Miller.

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LUNGS, DISEASES OF: ABSCESS.—Suppurative processes in the lungs are more common than is ordinarily supposed. The experienced clinician always keeps this fact in mind when dealing with acute inflammatory conditions, especially during convalescence.

ETIOLOGY.—An abscess always presupposes the presence of pus organisms.

1. Abscess occurs secondarily to diseases of the lungs proper, such as lobar and lobular pneumonia. It is not a common termination of lobar pneumonia; Osler found four cases in one hundred autopsies. On the other hand, it is extremely common in the aspiration and deglutition

forms of lobular pneumonia, such as occur following operations, under general anæsthesia, upon the mouth, nose, throat, and neck; also in wounds of the neck, suppurative processes of the nose, larynx, and even ear (Volkmann). Infective particles reach the bronchi, lodge there, and set up an inflammatory process, with abscess formation. Cancer of the œsophagus may penetrate a bronchus, with similar results.

Pulmonary tuberculosis at some time in its course usually becomes a mixed infection, with the development of abscess cavities, and symptoms of a septic process.

2. Metastatic abscesses develop in the course of a pyæmia, the infected material being distributed throughout the lungs by emboli. Similar abscesses are usually present in the various organs of the body, such as the brain, kidneys, spleen, etc.

3. Pulmonary abscess may develop as a result of the extension of the suppurative process from neighboring organs, or as an event secondary to the perforation of the lung by abscesses from without. Empyemas occasionally perforate the lung tissue and find a vent through the bronchi. Subdiaphragmatic and liver abscesses, associated with amœbic dysentery or echinococcus disease, may perforate the diaphragm and lung. The bronchi may simply furnish drainage for these abscesses. In the passage of infective material there may or may not be an infection of the lung with abscess development.

Pathology.—Abscesses occurring in the later stages of lobar pneumonia are not large, but are likely to fuse, and thus involve a considerable portion of one lobe. Tuberculous abscesses are situated most often near the summit, while other varieties are near the base.

Metastatic abscesses are usually very numerous, and, though scattered throughout the lungs, are frequently situated underneath the pleura; they are small, about the size of a pea.

The septic emboli may be associated with suppurative middle-ear disease, diphtheritic endometritis following childbirth, abortion, etc., or even with operations upon hemorrhoids.

Diagnosis.—A consideration of the history of previous diseases throws a great deal of light upon the case. The symptomatology is also important. One is likely to secure a history of a septic temperature curve, with chills and fever, occurring several times during the day. The presence of leucocytosis and the character of the expectoration may be of great assistance. The sputum is purulent, offensive, and at times contains large quantities of elastic tissue. The sudden perforation of an empyema or a subdiaphragmatic abscess into the bronchi may simulate an abscess of the lung.

The physical signs are very unreliable. The lungs, though riddled with metastatic abscesses, often give no definite signs of the condition. There may be diminished expansion, impaired resonance, weak breath sounds, tactile fremitus, and voice sounds. If the abscess is large and parietal, as in some cases of tuberculosis, one might get the signs of a cavity.

Prognosis.—Recovery occasionally occurs in the case of an abscess which has developed after pneumonia. The metastatic abscesses are of course almost invariably fatal. Single abscesses which discharge and are well drained may heal, with recovery of the patient.

Treatment.—Medical treatment is useless. If possible, such cases should be treated surgically with incision and drainage. *James Rae Arneill.*

LUNGS, DISEASES OF: AFFECTIONS OF THE BRONCHIAL GLANDS.

—(Syn.: Fr., *Adénopathie Trachéo-bronchique;* Ger., *Krankheiten der Bronchialdrüsen.*)

History.—It is to M. Noël Guéneau de Mussy that we are specially indebted for our knowledge of the diseases of the bronchial glands. M. Barety has supplemented his labors in a monograph, "L'Adénopathie Trachéo-bronchique," Tauchon (Paris, 1867), and others have described some of the changes in these glands which accompany phthisis in the adult, while MM. Rillet and Barthez, in their work, "Traité des Maladies des Enfants" (Paris, 1861), and Dr. West, in his Lectures on Diseases of Infancy and Childhood, have given full descriptions of the same changes in children under the head of bronchial phthisis.

Tumors and enlargements are more especially considered in connection with intrathoracic tumors. (See article on *Mediastinum, etc.*)

Classification.—Upon a pathological basis, diseases of the bronchial glands are classified under the conditions affecting lymphatic glands generally. They are subject to the following changes:

1. Inflammations: (*a*) acute; (*b*) chronic; (*c*) specific.
2. Morbid deposits and growths: (*a*) pigmentation; (*b*) cancer; (*c*) tubercle; (*d*) syphilitic growths (tertiary); (*e*) albuminoid disease.
3. Hypertrophy and atrophy.

Anatomy.—Since the greater portion of the symptoms arising from disease in the bronchial glands are due to implication of adjacent parts, either through inflammation or from pressure, exact knowledge of the anatomical relations is of the utmost value in determining the significance of any given symptom.

The largest group of glands lies just below the bifurcation of the trachea, between the right and the left bronchus. They are in relation, laterally, with the bronchi; anteriorly, with the pericardium, arch of the aorta, and pulmonary artery; and posteriorly with the aorta, vena azygos, œsophagus, and pulmonary plexus of nerves. Smaller ganglia are situated upon the anterior, posterior, and superior surfaces of the right and left bronchi. Those upon the right are the larger, and are in relation with the arch of the aorta, the brachiocephalic and subclavian arteries, the brachiocephalic and azygos veins, and the pneumogastric and recurrent laryngeal nerves. On the left they are in relation with the extremity of the arch of the aorta, the origin of the left subclavian and common carotid arteries, the subclavian vein, and the pneumogastric nerve with its recurrent branch.

Afferent vessels reach the glands from the lungs, pleuræ, neck, etc. The blood supply is through the bronchial arteries.

Pathology and Morbid Anatomy.—The pathological processes which occur in the bronchial glands are in no respect different from those which take place in other lympathic glands. The resulting anatomical changes assume special importance through their mechanical effects.

In many instances, when the glandular disease is slight, the anatomical disturbances cause such marked symptoms as to obscure, or divert attention from, the more serious associated conditions.

1. *Acute inflammation* is attended by cellular infiltration, with increase of lymphoid elements and retention of lymph, resulting in enlargement of the glands and softening of their parenchyma. When this process is rapid, or if due to specific poisons, suppurative and necrotic changes may follow. More commonly resolution takes place, and the glands return to their normal size.

2. *Chronic inflammation* is characterized by similar but more gradual cellular and lymphoid changes. In connection with these, fibrous growth is more marked; the glands become greatly enlarged, in some cases permanently, and their capsules are thickened and form adhesions with surrounding tissues. Resolution is seldom complete, and if it is long delayed the glands become contracted and indurated.

When suppuration results, the pus may find its way, by an ulcerative process, to the free surface of a bronchus, into the œsophagus or pericardium, or into the substance of the lung or lumen of a blood-vessel; or the contents of the abscess may undergo caseous, calcareous, or cystic degeneration. Even in the acute form suppuration rarely takes place with sufficient rapidity to allow rupture directly into the connective tissue, and in the chronic forms protective inflammation with adhesions is always present.

3. *The specific inflammatory changes* present no peculiarities in pathological processes.

4. *Pigmentation* (see also *Lungs, Diseases of: Pneumonokoniosis*).—Carbonaceous and other deposits in the bronchial glands seldom cause more than the lightest grades of inflammatory changes, owing to the slight irritating nature of the foreign matter and the slowness with which it is deposited. The glands become more or less enlarged and variously pigmented. In extreme cases they are entirely black, firm, hard, and gritty on section, resembling a lump of coal. The glandular tissue is partially atrophied and absorbed. When suppurative changes supervene, the discharge from the resulting abscess is at first black, and, though gradually becoming lighter, is not entirely free from pigment until the entire gland has been removed by suppuration.

5. *Cancer.*—Cancerous developments in the bronchial glands follow similar disease of the lungs, pleura, or mediastinum, and are of like character. Primary cancer is infrequent.

6. *Tubercle.*—Secondary tuberculosis occurs, to a greater or less degree, in all cases of pulmonary phthisis in the adult. In children, on the contrary, the glandular changes are often the more extensive and important. The process is commonly one of general infiltration, evenly distributed throughout the gland, but may start from several centres or be confined to one extremity of the gland. It is seldom that the deposit presents the form of gray miliary tubercle. In connection with these changes the glands enlarge, and at first are softer than normal, but, as the process advances and implicates the entire gland, they become firm and resistant, resembling tuberculous pulmonary consolidation. In the second stage the usual softening takes place, and tuberculous glandular abscesses are formed which follow the course of other abscesses described above.

7. *Syphilis.*—Syphilitic deposits are usually tertiary. Gummy deposits may lead to extensive enlargement, with subsequent caseous or suppurative degeneration.

8. *Albuminoid degeneration* is exceedingly rare. When present, the glands are usually enlarged, firm, and tense; occasionally they are atrophied. On section they present the usual waxy, glistening, homogeneous appearance, and give the characteristic reaction with iodine.

Etiology.—The lymphatic diathesis, inherited tendencies, and general malnutrition are here, as elsewhere in the body, predisposing causes of glandular disease. Some statistics have seemed to show a slightly greater predisposition among females, and an increasing liability to such disease after puberty.

West and others consider the disease to be very frequent among infants and young children.

Of the exciting causes, acute inflammation of the pulmonary tissue or pleura is the most frequent. Thus, a simple bronchitis, a pneumonia, a pleurisy, or an empyema, etc., may each be followed by an acute or chronic inflammation of the bronchial glands, resulting in resolution, abscess, or caseous degeneration.

So frequently have these glands been found enlarged in cases of whooping-cough that Noël Guéneau de Mussy was led to regard the spasmodic element in the cough as due to pressure upon the pneumogastrics by the enlarged glands.

Other observers (Barlow, *Lancet*, 1879, vol. ii., p. 124), however, have reported cases in which the pneumogastrics were not only pressed upon, but even involved in the inflammatory processes surrounding the gland, without the presence of any cough. Still further, many cases of whooping-cough, in which the spasmodic element was specially marked, exhibited no change in the bronchial glands post mortem. More exact observation also shows but little resemblance in the cough of pertussis to that due to irritation of the recurrent laryngeal nerve.

Both acute and chronic inflammatory changes have been observed in the bronchial glands in connection with most of the infectious diseases, more especially in typhoid fever, measles, scarlet fever, and pyæmia. In these conditions the changes are part of a generally lymphatic inflammation, and are seldom of sufficient extent to attract attention during the life of the patient.

Absorption of various forms of dust to which certain classes of workmen are exposed, with the consequent filling and clogging of the glandular passages, may lead to either acute or chronic inflammation, ending in atrophy or suppuration and abscess. Such a result is exceedingly rare, however, if we consider the number of cases of pneumonokoniosis in which the glands become partially or completely filled with extraneous matter.

As already indicated in the sections on classification and pathology, the specific causes of cancer, tubercle, syphilis, and amyloid degeneration are exciting causes of disease in these glands.

Finally, many cases of enlargement, induration, or suppuration with secondary changes will be found in which no exciting cause is apparent beyond the lymphatic diathesis. Simple inflammation seldom causes suppuration, such a result following more certainly from septic irritation, as in pyæmia or tubercle.

Symptoms.—In the earlier stages, and, indeed, throughout the entire course of the disease, unless the glands form decided tumors, the symptoms will be almost entirely rational. Since they are due solely to pressure, and as the glands involved in different cases will not be the same, nor always enlarge in the same direction, it is evident that the symptoms will vary greatly in their order of development and relative importance in different cases.

1. *Cough* is the most frequent as well as the earliest symptom. This may be due to pressure upon either a bronchial tube or the recurrent laryngeal nerve. In the former case it will resemble the cough of simple bronchitis. When due to pressure on the nerve it will be more harsh and laryngeal in character, and in some cases will have a distinct spasmodic element. When the irritation is severe it may be a persistent dry hacking, with or without paroxysmal exacerbations. More rarely it is deep, hollow, and metallic, or resembles the cough of an animal.

2. *Expectoration* attending the bronchial form of cough is quite constant. At first white and frothy, it gradually becomes muco-purulent when the glandular processes are acute and rapidly extending, or changes to a tenacious, mucous sputum with the more chronic processes. Should a glandular abscess open into the bronchial tubes, it will be evidenced by a more or less free purulent expectoration, mingled, it may be, with cheesy or even calcareous matter. After such an opening has occurred, an intermittent purulent discharge will continue indefinitely, or until the abscess has healed. When cough is due to nerve compression, expectoration is slight or entirely absent. No appreciable modification in the expectoration will be observed when the glandular disease is secondary to other pulmonary lesions.

3. *Hæmoptysis* is present in a small proportion of cases. When due to intense pulmonary congestion, resulting from prolonged paroxysms of coughing or obstruction to the pulmonary veins, it is usually capillary in character, and appears at first either as streaks in the sputa or in moderate amount as clear, bright-red blood, followed later by darker masses and small clots. When due to bronchial ulceration or erosion of a vessel in the wall of a glandular abscess, it is more profuse in character, appears suddenly, and may continue for several days, or even result in death.

4. *Pain* is one of the most frequent symptoms. In character it does not differ from that occurring with other forms of intrathoracic tumors. It has been described as dull and heavy, as a tightness or compression, and in a few cases has been spasmodic.

It is usually associated with some decided tenderness on pressure, and when once present is quite persistent, even when varying greatly in intensity.

It is most frequently located posteriorly between the spine and border of the scapula, opposite the bodies of the fourth, fifth, and, in a few cases, the sixth dorsal vertebræ. Less commonly it is felt in front, near the edge of the sternum, or under the clavicle, with occa-

sionally a point of pain and tenderness in the axillary region, causing it to simulate intercostal neuralgia.

5. *Dyspnœa* is often a prominent symptom. One fatal case is reported in which it was the only symptom. Its intensity depends less upon the absolute size of the tumor than upon the direction and nature of the enlargement. A comparatively small tumor or rapid inflammatory exudation may compress a primary bronchus sufficiently to cause most intense dyspnœa.

When due to compression of a bronchial tube, or of the lung substance, the dyspnœa is persistent and unvarying. In a small proportion of cases it appears to depend upon implication of the laryngeal nerve and unilateral paralysis of the larynx. It may be paroxysmal, or even assume the characteristics of spasmodic asthma with decided nocturnal paroxysms, and it is occasionally so severe as to force the patient to assume the erect position. Quain gives the proportion in which this spasmodic element is well marked as one in fifteen.

6. *Dysphagia* is a quite common symptom, and is due simply to compression. It is present in about fifteen per cent. of cases. It comes on slowly, is persistent, and varies only with the changes in the size of the glandular tumor. It is first noticed and most marked as regards solid food, but in one or two cases it was almost confined to liquids.

7. *Change of voice* is present only when the recurrent nerves are implicated. There may be loss in volume and force in connection with the dyspnœa of bronchial obstruction, but distinct changes in character are probably always of nervous origin.

Hoarseness is the earlier and may be the only change. It occasionally passes into complete aphonia. In these cases paralysis of one or both vocal cords can be recognized by the laryngoscope.

8. *Nausea and vomiting* are rare symptoms, due to implication of the pneumogastrics. M. de Mussy considers them more frequent when the left nerve is affected.

9. *Venous Compression.*—Compression of the ascending veins seldom causes any marked symptoms. Anorexia and the general disturbances of digestion have only an indirect relation to venous obstruction.

Compression of the veins coming from the head is more frequent, causing cyanosis, congestion, and œdema of the face and neck, and rarely of the upper extremities. Epistaxis results from the same cause.

Physical Signs.—*Inspection* is usually negative. It may show: 1. The œdema, puffiness, etc., just mentioned, of the face. 2. Slight prominence of the upper sternal and infraclavicular regions. This is exceedingly infrequent; it was noticed in none of sixty cases reported by Quain. 3. Slight flattening of the affected side. It is the more frequent change, and is probably induced by bronchial occlusion and partial pulmonary collapse. 4. Diminished motion of the affected side. It may be present alone or in connection with either enlargement or contraction. 5. No change in either size or motion. Most cases will be of this nature.

Palpation will show decreased vocal fremitus when bronchial compression has resulted in occlusion of the tubes.

Percussion.—Dulness is the most constant physical sign, and will indicate, by the area over which it is present, and by its character, both the size of the glandular enlargement and its nearness to the surface. It is usually best marked behind, between the scapula and spine, extending in extreme cases from the fourth to the sixth, or even seventh, dorsal vertebra. Less frequently it may be obtained in front, over the manubrium sterni, and below the sternal end of the clavicle.

Rarely pulmonary collapse causes partial dulness over a greater or less area. Abscess cavities communicating with the bronchial tubes are seldom, if ever, of sufficient size to affect the percussion note.

A compensatory emphysema may possibly give a vesiculo-tympanitic tone over the healthy lung.

Auscultation.—The respiratory sounds will be variously modified by the size of the tumor and its relations to the pulmonary tissue and bronchial tubes.

Weakness or entire absence of vesicular murmur is the more frequent change. It is due principally to bronchial obstruction, but in some cases is caused by direct compression of the pulmonary tissue. In the former case the change may be observed over a considerable area, or even an entire lung, but in the latter it will be more localized.

In an almost equal number of cases the respiratory sounds are loud and harsh, or even distinctly tubular. These changes are found only over the seat of the disease, and depend upon compression and closure of the alveoli and smaller tubes.

A venous hum, heard best at the root of the neck, and more common in children, is usually present when there is decided compression of the descending venous trunks.

Bilateral examination of the chest with the *x*-ray will often reveal a thoracic tumor and locate it on or about the bronchial tubes.

Diagnosis.—It is evident from the foregoing description that, in the earlier stages at least, a positive diagnosis is impossible. In no two cases will the symptoms or their order of development be alike.

They indicate only some form of intrathoracic growth, and may all be present with mediastinal tumors or thoracic aneurism.

Mediastinal tumors are more frequently primary, those of the bronchial glands secondary.

Malignant growths are more common in the mediastinum, while inflammatory processes and tuberculous deposits more frequently affect the bronchial glands.

With mediastinal growths, especially of the anterior mediastinum, disturbances of circulation usually precede those of respiration, the contrary being the rule in disease of the bronchial glands.

Although both show a tendency to extend inward, mediastinal tumors are much more frequently attended by enlargement and bulging of the chest wall.

Distinct physical signs can usually be obtained earlier in mediastinal than in glandular disease.

In thoracic aneurism, also, the early symptoms are those connected with the circulation, while respiratory disturbances, both subjective and physical, are developed late. The arterial murmur, aneurismal bruit, with a thrill and heaving impulse on palpation, is a valuable point of differentiation. In aneurism the area of dulness increases along the course of the artery or rises into the neck, while in bronchial-gland enlargement it is more fixed, increases less laterally, and is more common behind than anteriorly. Diminution and delay of the radial pulse upon one side and cardiac hypertrophy are occasional symptoms of thoracic aneurism.

Erosion of the sternum, so frequent with aortic aneurism, does not result from disease of the bronchial glands.

Prognosis.—The most important element in prognosis will always be the nature of the pathological process.

Malignant disease here, as elsewhere, terminates fatally, and tuberculosis will have a similar ending. Syphilitic growths, simple enlargements of scrofulous origin, and subacute inflammatory processes may often be arrested and a practical cure effected when the nature of the disease can be recognized early. In such cases the extent of the growth, the rapidity with which it is extending, and its relations to and effects upon adjacent tissue must form the basis of any prognosis. The more serious complications are those arising from implication of the laryngeal nerves and obstruction of the vessels. Glandular abscesses which open into bronchial tubes may be followed by recovery, but are more frequently fatal, either immediately or from prolonged suppuration and exhaustion.

Treatment.—The cases in which treatment has proved distinctly effective have been simple chronic enlargements. The iodides, with iron and cod-liver oil internally, and counter-irritation between the scapulæ, have been the most successful measures employed. The iron and iodine may be given separately or in combination. For syphilitic cases, in which large doses of iodide are

required, the former method is to be preferred, but in scrofulous disease the syrup of the iodide of iron may be given with equally good results.

Cod-liver oil is always a valuable remedy, and especially so with children and in the lymphatic diathesis. Even cases of tuberculosis may be delayed and greatly benefited for a time by its use, and, whatever the nature of the disease, the oil may be employed with success for its general nutritive effect.

The persistent use of small (gr. $\frac{1}{60}$ to $\frac{1}{40}$) doses of the bichloride of mercury has occasionally benefited some cases even when no syphilitic element was present, and this plan may be tried when the iodides are unavailing.

Counter-irritation over the seat of the disease is always of decided value. It may be obtained by the use of any of the more persistent counter-irritants, as the tincture of iodine, iodine liniment, blisters, or the actual cautery.

The special symptoms require palliative treatment.

The cough is seldom relieved by expectorants, and is best controlled by sedatives and antispasmodics. Codeine, heroine, morphine, and chloroform inhalations, in the spasmodic form, are the most certain in their effects, but the bromides, belladonna, Hoffman's anodyne, or chlorodyne are of value, and may suffice in some instances.

Pain is best relieved by anodyne lotions, and when severe by hypodermics of morphine. For local applications, laudanum, belladonna, chloroform, or camphorated liniments may be employed.

Dyspnœa is more safely relieved by chloroform inhalations and the ethereal preparations than by opium or other narcotics.

The enforcement of general hygienic and tonic measures will greatly increase the efficacy of any form of treatment. *Charles E. Quimby.*

LUNGS, DISEASES OF: BRONCHIAL PNEUMONIA. See *Pneumonia, Bronchial.*

LUNGS, DISEASES OF: CHRONIC PNEUMONIA. See *Pneumonia, Chronic.*

LUNGS, DISEASES OF: EMPHYSEMA. See *Emphysema of the Lungs.*

LUNGS, DISEASES OF: GANGRENE.—Gangrene of the lung takes place whenever the nutrient circulation in a given area is interrupted. It does not follow directly upon obstruction of the *functional* vessels, although obliteration of a considerable branch of the pulmonary artery may afford a nidus for putrefactive germs, and thus entail gangrene as a secondary result. In a considerable proportion of cases it occurs as a complication of pneumonia, the intensity of the infection at a particular point being such as to compromise the vessels that feed the tissues of the lung. If pneumonia were an "inflammation" of the lung substance, inducing such a disturbance of nutrition as the amount of exudation implies, gangrene would be the issue in every case.

Etiology.—Gangrene appears as the initial local condition in many forms of infectious disease. It may occur in the course of any debilitating disease or during convalescence from protracted fever. It is an occasional event in nearly all of the exanthemata, and also in diabetes mellitus. It is observed frequently in aspiration pneumonia, putrefactive material having been implanted in the air passages (Osler*).

The putrid contents of bronchiectatic cavities may induce gangrene in neighboring parts of the lung. The breaking down of cancerous growths communicating with the air passages may produce a like effect. Sometimes there is no assignable cause. Embolism of a bronchial artery, which would be easily overlooked, might explain some of the cases.

Pathology.—Two forms of pulmonary gangrene are described, the diffuse and the circumscribed. The former may take in a large area of lung. It is more common in the lower lobe, and in the outer portions of the lung rather than in the centre. It tends to form an irregular cavity with ragged and sloughy contour. The putrid tissue is dark green in color, approaching black, and it drips with a greenish and exceedingly ill-smelling fluid. Surrounding this gangrenous area is one of intense congestion, and the lung beyond this is œdematous. The bronchial membrane throughout the entire lobe is infected by the ichorous fluid passing over its surface and is intensely congested and covered with muco-purulent material.

The destruction of tissue is likely to lay open vessels of considerable size, and sudden and profuse hemorrhage may occur. The pleura may be perforated, and, its cavity being infected with germs of the most virulent character, the pleurisy which follows is rapidly fatal.

From the gangrenous focus extensive embolic processes may occur, resulting in secondary abscesses in different localities.

In the circumscribed form the destruction of tissues is not so widespread, and the resulting cavities are more sharply defined. This form is most likely to occur in the course of lobar pneumonia, when the bacteria of putrefaction will usually be found associated with the pneumococcus. It is this association probably which gives increased virulence to the infection and induces stoppage of a branch of the bronchial artery.

Course of the Disease.—The accession of gangrene is usually announced by the fetid character of the breath. The odor is pungent and peculiarly sickening, and pervades the room and sometimes the whole house, making it almost intolerable for the attendants. This is soon followed by a greenish-black putrid expectoration containing shreds of lung tissue and particles of a more solid material. The lighter portions rise to the surface, forming a greasy layer in which the microscope shows abundant crystals of fatty acids. The heavier detritus, including elastic fibres from the broken-down tissues, sinks to the bottom, and between these two layers is a watery stratum of a greenish color. The quantity of expectoration is large, amounting to ten or even twenty ounces in twenty-four hours. There may be, however, small foci of gangrene discovered post mortem which have not communicated with a bronchial tube, and consequently have not been accompanied by fetid breath (Osler).

The physical signs are those of infiltrated lung tissue combined with those of a cavity. Cavernous respiration may be modified by the shreddy character of the walls, and usually lacks the distinct quality met with in tuberculous excavations with rigid boundaries. Small circumscribed areas may present no definite physical signs other than those of bronchial infection.

Fever of a moderate degree and variable in its course is usually present, but in encapsulated cases there may be no rise of temperature. The absorption of infective material may give rise to typhoidal symptoms.

Irritation of the stomach and intestines is apt to arise from swallowing putrid matter coughed up from the lung. Secondary abscesses may occur, especially in the brain.

The diagnosis is principally from fetid "bronchitis." In the latter the fetor is not so extreme, and the expectoration does not contain shreds of lung tissue. The affection is also not so acute and produces less constitutional disturbance. The secondary infections at distant points are absent.

In some cases of small encapsulated foci the diagnosis is extremely difficult and may be possible only at autopsy.

Prognosis.—Gangrene of the lung when extensive is generally fatal. Death may be the result of sepsis from absorption of gangrenous material; of a rupture into the pleura, pericardium, or peritoneum; of hemorrhage; or of an exhausting infective diarrhœa. Occasionally even a large cavity heals completely, and the patient recovers. According to Strümpell,* in encapsulated cases

* "Practice of Medicine."

* "Text-book of Medicine," 3d American edition. D. Appleton & Co., New York, 1901.

the question of recovery or death may not be determined for months or even years. Small foci may be discovered at autopsy which have not been suspected during life.

Treatment.—As to treatment, much may be done in the way of prophylaxis in cases in which there is special danger of aspiration pneumonia, as, for example, in the insane and in the subjects of bulbar paralysis, and in recovering from anæsthesia. Care in the selection, preparation, and administration of the food in such cases will greatly lessen the liability of foreign matter being drawn into the air passages.

When the disease is actually present every effort should be made to keep up the strength of the patient, as in this lies our principal hope. Concentrated liquid food and alcoholic stimulants will be required. Quinine, strychnine, and carbonate of ammonia will be useful. Antiseptic remedies that are eliminated through the lungs promise more than any other form of medication. Among these are creosote, creosotal, turpentine, carbolic acid.

Inhalations of various antiseptics are usually employed, but it is difficult to make them penetrate into the affected portion of the lung.

Creosote, eucalyptol, menthol, iodine, bromine, formaldehyde have been recommended, but they exert their effect much more upon the healthy than upon the diseased areas, and unless greatly diluted will cause irritation which may be hurtful out of proportion to the good the inhalations accomplish. Inhalations of pure oxygen are indicated aside from any effect in relieving dyspnœa, as oxygen locally applied has been proved useful in improving the nutrition of foul, sloughing surfaces.*

Sheets dampened with solutions of deodorizing substances, such as the chlorides, and hung about the room, will relieve in a measure the sickening fetor of the atmosphere, and contribute to the comfort of the attendants as well as of the patient.

There may be room for possible benefit from surgical interference, particularly in protracted cases.†

Andrew H. Smith.

LUNGS, DISEASES OF: HYPERÆMIA.—There are two kinds of congestion, active and passive.

1. *Active Congestion* of the lungs is a condition concerning which there is not a unanimity of opinion. Osler and other American and English authors believe that it is simply part and parcel of some other inflammatory disease of the lungs, such as pneumonia, bronchitis, tuberculosis, pleurisy, etc.

Acute congestion of the lungs and congestive chills were once familiar diagnoses. We now know that they are usually the initial symptoms of some acute infectious process, such as pneumonia. A case in point has recently come under my observation. An extremely severe chill followed by high fever was called a congestive chill. In a few hours distinct signs of pneumonia were present, with diplococci in the sputum. The disease, however, aborted in from twenty-four to thirty-six hours. Such a case would be termed acute congestion by the French writers, who give this condition the dignity of a disease *per se* (maladie de Woillez). They describe a definite symptomatology, such as initial chill, pain in the side, cough, dypsnœa, and slight elevation of temperature, 101°–103° F. The physical signs are indefinite, such as impaired resonance, weak vesicular or blowing breathing, with crackling râles. These signs, however, can all be associated with just such anomalous cases of pneumonia as above mentioned. In many epidemics these larval cases are common.

It is stated by some authors that a rapidly fatal congestion may follow extreme exertion, or exposure to excessive heat or cold. Leuf reports cases in which, in association with drunkenness, exposure, and cold, death occurred suddenly, or within twenty-four hours; post mortem an extreme congestion was the only pathological condition found.

2. *Passive Hyperæmia or Congestion.*—There are two forms: (*a*) Mechanical; (*b*) hypostatic.

Mechanical.—Etiology. In the passive form there is an excess of venous blood in the lungs due to obstruction to the flow of blood into the heart. Mechanically, this results from the presence of chronic valvular lesions of the heart in which incompensation has taken place. Lesions on both sides may produce this result. It will also occur in myocardial degeneration with incompensation and the development of relative insufficiencies. Emphysema may also be responsible for this condition. Brown induration of the lungs is a sequel. Osler describes such a lung as voluminous, russet-brown in color, cutting and tearing with great resistance. On section, it shows at first a brownish-red tinge, and then the cut surface, exposed to the air, becomes rapidly of a vivid red color from oxidation of the abundant hæmoglobin. Histologically, it is characterized by (*a*) great distention of the alveolar capillaries; (*b*) increase of the connective-tissue elements of the lungs; (*c*) the presence, in the alveolar walls, of many cells containing altered blood pigment; and (*d*) the presence, in the alveoli, of numerous epithelial cells containing blood pigment in all stages of alteration, which are also found in great numbers in the sputum.

The presence of tumors may cause a local congestion.

The symptoms of this passive form develop with incompensation and are dyspnœa, cough, expectoration, etc.

(*b*) *Hypostatic Congestion.*—In conditions of great weakness of the heart, such as follow the various acute fevers, anæmias, cachexias, Bright's disease, prolonged coma, etc., there is a transudation of serum from the bloodvessels into the dependent tissues of the body. This is of course favored by gravity, but is not essentially dependent upon it, since a healthy man may be in bed for weeks without its development. If the thorax of such a patient be examined there will be found, posteriorly and in the axillæ, impaired resonance, feeble breath sounds, and numerous crackling râles. The tactile fremitus is perhaps somewhat diminished. When the transudation is extensive and of long duration the dulness may become marked, with weak blowing breathing; it is now termed hypostatic pneumonia. This condition is usually a part of a more general transudation of serum. It must be distinguished from atelectasis, since in all inactive individuals fine crackling râles are frequently heard at the lower borders of the lungs. Hydrothorax and pneumonia must also be excluded. There are no special symptoms of this condition and it is often discovered only by careful examination.

Osler refers to the forms of passive congestion which occur in injury to and diseases of the brain. In prolonged coma there may be an association of patches of consolidation along with the congestion, due to the aspiration of particles of food.

Pathology. The posterior portion of the lung is dark in color and engorged with blood and serum; part of it may even sink in water, when it is termed splenization, or hypostatic pneumonia.

Treatment. This consists in the treatment of the primary disease; with its improvement the signs and symptoms of the congestion disappear. If the symptoms are severe and are secondary to incompensated valvular affections, venesection, with the removal of from twenty to thirty ounces of blood, may reduce the congestion and relieve the right heart. *James Rae Arneill.*

LUNGS, DISEASES OF: INFARCTION.—Infarction (*in*, and *farcire*, to stuff) of the lung consists in a "hemorrhagic engorgement" of a circumscribed area of pulmonary tissue. Although first classically described by Laënnec in 1819, it appears that the condition was characterized by him as that of an apoplectic area, being compared to cerebral apoplexy. Laënnec dwelt upon the venous thrombosis in such cases, apparently disregarding completely the arterial occlusion upon which now so much stress is laid.

* Demarquay: "Pneumatologie Médicale."
† Am. Journ. of the Medical Sciences, March, 1902, p. 375.

Pathology and Pathogenesis.—Pulmonary infarcts are found usually in the lower lobe of the right lung when no previous disease, such as pleurisy, previous infarction, etc., has weakened the strength of the stream in the right pulmonary artery. The gross appearances of pulmonary infarcts are generally characteristic. While they vary somewhat in shape and position, yet it may be said that they are chiefly wedge-shaped and peripherally situated. The apex of the wedge is embedded in practically normal pulmonary tissue, while the base is at the pleural surface of the lung, presenting an area of dark red or purplish color, somewhat elevated above the surrounding parts. Some infarcts are conical and many of these are found deep in the lung substance.

When recently formed, infarcts are hard and swollen and sharply defined, and on section the surface is smooth or slightly granular and of a deep, dark red or purple color, with an appearance often of a dense blood clot. It is rare to find but a single infarction of the lung. They are usually multiple. In size they vary within wide limits, although it may be said that they are generally from one to four cubic inches in measurement; they have, however, been described as occupying the greater part or the whole of one lobe.

When examined microscopically the tissues within the area of infarction are found filled or stuffed with blood, the capillaries engorged, and the air cells distended with red corpuscles; some of the vessels, however, may be quite empty. The bronchi are often seen more or less filled with a flaky substance in which blood and epithelial cells in various stages of disintegration may be found. When subjected to a staining process, the signs of necrosis are observed in the failure of cells and nuclei to stain normally. This is often first seen about the centre of the infarct. In the older infarcts the hyaline thrombi of von Recklinghausen, by whom they were regarded as causative factors, are seen in greater or less numbers, while fibrin is present in abundance. The vessels of the pleura are also greatly congested in many specimens, and in the pleura itself signs of thickening with inflammatory exudate are common.

After Laënnec, Cruveilhier explained infarction in the lung by attributing it to a primary inflammation of the vessels, chiefly the venous capillaries, and accounted for all clots or coagula within the vessels upon this ground. It remained for Virchow, several years later, to refer these changes, included under the term "infarction," to disturbances of circulation induced by embolism or thrombosis. At the same time it appears that Virchow left the question of the relationship between embolus and infarction an open one, although it would appear from certain comparisons made that, in the great majority of cases at least, he regarded this relationship as one of cause and effect.

From the time when these views were set forth (*i.e.*, about 1856) until even the present, hemorrhagic pulmonary infarction, so far as its relation to embolism and thrombosis is concerned, has been under discussion and many views have been advanced.

The following are the most important of these: Cohnheim, alone and with Litten, came to the conclusion, on experimental grounds, that the pulmonary artery belonged to that group of arteries in different organs known as *end arteries*, and that occlusion of such arteries was especially favorable to the formation of infarcts of the hemorrhagic variety. The vessel wall, thus robbed of its nourishment, permitted the blood which came as a venous reflux to pass through it and out into the tissues. Hence venous reflux and occlusion of an end artery constituted the main points in this view.

In an article published in 1891, P. Grawitz maintained that in order to induce or to have induced in the lung the condition of infarction, an abnormal condition of the pulmonary tissue must be present, such as the brown induration of heart failure, inflammation of the lungs, chronic bronchitis, etc. Grawitz found the blood-vessels which he regarded as the source of the hemorrhage, in the newly organized and vascularized tissue incident to chronic bronchitis, that is, in peribronchial, subpleural, and interlobular fibrous tissue. Given, then, such a state of lung tissue with a disease of the heart, such as mitral regurgitation or stenosis, and all the conditions were fulfilled for a hemorrhagic infarct. And should such an infarct be found with an embolus in the artery leading thereto, he would say, "an infarct in spite of the embolus."

Gsell, in his work published in 1895, maintains that typical hemorrhagic infarcts may result from emboli in some branch of the pulmonary artery, but that they are much more likely to occur, and to occur in greater numbers, when there is an abnormal condition in the pulmonary tissue, as hyperæmia, atelectasis, etc.

Some of the above-mentioned observers, together with several others, attempted a solution of this question from the experimental side with various and hence confusing results. Fujinami, in 1898, published the results of his researches, which included experiments upon eighteen dogs and five cats. In addition to these he carefully examined thirteen cases of infarct of the lungs found in the human subject. This very careful study resulted in establishing beyond doubt that a pulmonary infarct is a consequence of circulatory disturbances in the capillaries in certain areas. This occurs in many instances as a result of emboli occluding branches of the pulmonary artery, even in a healthy lung. There are certain conditions, however, which aid in bringing about these circulatory disturbances.

It has been seen from the above cursory review of this part of the subject that much interest has centred about embolism as a causative factor; and that both experimentally and clinically embolism is established as a cause of pulmonary infarction. The evidence is not so clear, however, when one turns for proof of those other causes of infarction, viz., thrombosis of the pulmonary artery and the occlusion of a terminal bronchus, bringing about atelectasis.

It must be admitted that thrombosis of the pulmonary artery may occur apart from embolic processes; but, according to the present consensus of opinion, this is not a common finding. Thrombosis of this vessel, when found under such conditions, may be said to fall under one of the following classes:

1. Hemorrhage between the adventitia and the media, occurring as a result of pulmonary disease to which the arterial change is secondary; or a primary hemorrhage in this vessel, resulting in an occlusion of its lumen through pressure upon the media.
2. Endarteritis, or fatty degeneration of the artery.
3. Chronic lymphadenitis involving the vessel walls.

Atelectasis acts but rarely as a cause of infarction. When it does so it is doubtless through the absorption of air and the resulting alterations in blood pressure in the affected part, whereby some blood is extravasated into the tissues. There is reason to question this mode of production, or, even accepting this as a cause of hemorrhage, to disregard such hemorrhages as those of infarction.

Before leaving this part of the subject, we must consider the source of the blood in pulmonary infarction, as well as the mode by which it gets into the tissues. We have already referred to the view expressed by Grawitz, who maintains that the newly vascularized tissue formed as a result of pulmonary disease gives rise to the hemorrhage. The vessels in this tissue rupture under increased pressure.

Hamilton, of Aberdeen, scornfully dealing with the embolic theory of infarction, states that the blood gushes out of the overdistended pulmonary capillaries in heart disease and takes the characteristic wedge shape because it is effused into a certain space corresponding, not to the distribution of a terminal artery at all, but to a group of alveoli about a terminal bronchus.

Earlier writers upon this subject would account for the hemorrhagic character of the infarct by a reflux of blood in the veins of the affected part; but, in more recent times, this view has been set aside by careful experiments and close observation. Regurgitation does not

take place through the veins. The capillaries, along with any arterial anastomoses, supply the blood and the red cells pass out by diapedesis which, as Welch has pointed out, is greatly favored by slowing and stagnation of the blood current and a high intracapillary and intravenous pressure.

CLASSIFICATION.—Pulmonary infarcts are usually red or hemorrhagic. It is rare that an opportunity is afforded one of studying an anæmic or white infarct of the lung, although it does occur. Freyberger's report, published in 1898, presents a good example of this variety. It is his view, as the lung in his case contained in all twenty-two infarcts, and but one of them was white or nearly so, that this was the last one formed; and, as the patient died a lingering death, the circulation had become so weak that anastomoses could not be established. The writer suggests, partly as a result of a study of this observation, that, at the first instant or so of formation, all pulmonary infarcts are anæmic.

Changes in Infarcts.—One rarely finds in the lungs signs which one must regard as those marking the site of a former infarct. However, such are occasionally discovered, a small fibrous pigmented scar being the only evidence of former circulatory disturbances. There seems to be little doubt but that the smallest may undergo resolution, yet the larger ones rarely do. They may become organized in part or again gangrene may result or an abscess may form in the area of infarction and subsequent infection. In a lung taken from the body of a person dead from cardiac disease, and examined while this article was in preparation, a deep red, wedge-shaped area, fluctuating and very soft to the touch, was discovered near the apex of the right upper lobe. When this portion of the lung was cut into it was found to contain a dark brownish fluid—the liquefied infarction clot. Leading up to it a branch of the pulmonary artery was occluded by a small embolus. The right auricle contained a thrombus.

Conditions Favoring Infarction.—From what has been already stated it may be concluded that cardiac disease, in which the pulmonary circulation is abnormally altered, favors infarction. There is a heightened venous and capillary pressure under such circumstances. Then again, thrombi not infrequently are found in the right auricle. Chronic pulmonary disease may also be induced by the cardiac state. Thrombosis in the systemic veins, from any cause, may give rise to the pulmonary affection. Diseased conditions in the pulmonary artery itself, rapidly inducing thrombosis, favor infarction.

It must be borne in mind that embolism and thrombosis may each take place in the branches of the pulmonary artery without infarction occurring. In one case infarction does not occur, as the circulation is completely established, while in the other death may quickly supervene, affording no occasion for such changes.

SYMPTOMS AND SIGNS.—In many cases there are no clinical features whatever to denote the pulmonary changes incident to infarction. Intense thoracic pain with pronounced dyspnœa may usher in the closing scene of a case of chronic cardiac disease or one of venous thrombosis. Such cases terminate with signs of asphyxia or syncope. In other cases partial recovery may follow the alarming and distressing onset and in a short time—the space of a few hours—dark red blood may be expectorated. Of thirty-seven patients dying with pulmonary infarction in the Royal Victoria Hospital, only fifteen expectorated blood. The temperature usually remains undisturbed, but later it may become febrile as a result of the process of gangrene or abscess formation. Pain in the side is often complained of, while a pleural friction sound may mark more definitely the site of infarct. Dulness on percussion and blowing breathing are often present. Fine moist râles may be heard. The breath sounds may be absent.

DIAGNOSIS.—The greater number of pulmonary infarcts are latent. Of thirty-seven cases showing this condition in the lungs at autopsy in the Royal Victoria Hospital, only four were recognized definitely before death. Sudden and severe dyspnœa was noticed in four, while pain over the region of the infarct was felt in two cases.

One must exclude asthma, coronary-artery disease, and pneumonia. As a rule this is not difficult. The history and the course, and, in the case of asthma especially, the physical signs, are characteristic.

PROGNOSIS.—Much depends upon the extent of the infarct, the condition of the heart and lungs, and the possibility of recurrence in other parts.

TREATMENT.—A word in this connection may be said regarding prophylaxis. There can be but little doubt that early or violent movement of a limb whose vein is thrombosed, or massage over such an obstruction, may occasion embolism. Hence the necessity of an intelligent and careful treatment of such cases. Well advanced involution of the parturient uterus should be secured before the patient is allowed to get out of bed and move around. One must seek to maintain the compensation of the heart in cases of endocarditis. Since so little can be done by active treatment of infarction, the object should be to prevent its occurrence.

In addition to these measures for prevention, treatment consists in but little more than the relief of symptoms and chiefly that of pain. *William Fawcett Hamilton.*

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LUNGS, DISEASES OF: LOBAR PNEUMONIA. See *Pneumonia, Lobar.*

LUNGS, DISEASES OF: ŒDEMA.—ETIOLOGY.—This occurs in practically the same diseases as does passive congestion. The two conditions have much in common. When occurring in the neighborhood of inflammations, tubercles, new growths, infarcts, etc., it is termed collateral œdema. It is a common complication of chronic Bright's disease, chronic heart disease, very severe anæmias, cachexias, and cerebral affections. The pre-agonal form is common and does not cause the patient's death, but occurs because he is dying.

PATHOLOGY.—There is usually an hydræmic state of the blood, with increased intrapulmonary pressure. Welch thinks that the essential factor lies in a disproportionate weakness of the left ventricle, so that the blood accumulates in the lung capillaries till transudation takes place.

The lung is heavy, pits on pressure, and the involved parts are filled with serum; if the œdema is associated with congestion the serum has a reddish color. The lung may have a gelatinous appearance.

DIAGNOSIS.—The symptoms are very indefinite and cannot be dissociated from those of the primary disease; there is perhaps an increase in the severity of the cough and dyspnœa. Large quantities of sero-mucoid fluid are expectorated.

The physical signs are not remarkably characteristic. The presence of numerous fine, moist, uniform râles in the dependent portions of the lungs, in association with œdema in other parts of the body and secondary to heart or kidney disease, is very suggestive of pulmonary œdema. The breath sounds are usually weak. Percussion may be negative, unless hydrothorax or hypostatic pneumonia is present, when dulness will be elicited.

Pulmonary œdema may occur suddenly, with a rapidly fatal issue.

TREATMENT.—It is that of the primary disease.

James Rae Arneill.

LUNGS, DISEASES OF: PNEUMONOKONIOSIS.—DEFINITION.—Etymologically, pneumonokoniosis is a general term indicating deposit of dust within the pulmonary parenchyma. Owing, however, to the intimate etiological relations which such deposit bears to subsequent pathological changes, the term is commonly used as including the earlier stages of the diseases thus arising.

SYNONYM.—The specific term anthracosis is often and, indeed, usually employed for the generic and more cumbersome one originally proposed by Zenker.

CLASSIFICATION.—As the pathological processes and anatomical changes do not differ in character, whatever the nature of the foreign matters, the classification is based upon the form of the inspired dust, and may be extended almost indefinitely.

The more common forms are anthracosis (ἄνθραξ, coal), due to a deposit of coal or other carbonaceous dust; siderosis (σίδηρος, iron), applied to all metallic dusts as well as iron; chalicosis (χάλιξ, gravel), including the various forms of mineral dust; byssinosis (βίσσος, cotton), due to cotton or other vegetable fibre; tabacosis, inhalation of snuff or tobacco dust. Deposits of any other form of dust may receive similarly appropriate names.

On account of the evident relations which certain diseases bear to dusty occupations they have received such characteristically descriptive names as miners' or stonecutters' phthisis, masons' or millers' lung, potters' asthma, buffers' consumption (among metal polishers), Sheffield grinders' rot, and elevator disease, or "scoopers'" pneumonia.

HISTORY.—Both physiological experiment and post-mortem examinations have conclusively proved that foreign matters inhaled in fine subdivision, not only pass to the bronchial surfaces, but also reach the alveolar cavities, enter the pulmonary parenchyma, and are finally lodged in the bronchial glands. The relations of such dust deposits to various forms of chronic lung disease have long been recognized. Hilaire (Paris, 1845) and Vernois (Paris, 1858), among earlier writers, and more recently Michel (Bonn, 1872), Kuntzen (Berlin, 1873) ("Handb. d. spec. Path.," Ziemssen, Leipzig, 1874), Roy (Bordeaux, 1884), Perissé (Bull. Soc. de Méd., Paris, 1894), and others have described both the pathological changes and the clinical manifestations of pneumonokoniosis in its chronic form. We are indebted to Rochester (Buffalo, N. Y.) for much of our knowledge of the more severe acute conditions. The changes caused by infective elements of dust do not receive consideration in the present article.

PATHOLOGY AND MORBID ANATOMY.—It is not possible to suppose that any dust can pass by direct inhalation beyond the second or third bifurcation of the bronchial tubes, or that it remains suspended in the residual air. The first point of deposition must be, then, upon the bronchial mucous membrane, at some considerable distance from the alveoli. The larger portion is here taken up by the mucous corpuscles, or becomes entangled in the bronchial secretion and is thrown off in the expectoration. More or less, however, makes its way along the bronchial tubes, notwithstanding the opposing action of the cilia, and although it is gradually lessened in amount by expectoration a small residue eventually reaches the alveolar cavity, where the particles may be found closely adherent to the epithelial surface.

Occasionally this distribution occurs quite evenly throughout the lung, but more commonly the apices receive the larger portion, which by gradual increase becomes in some cases sufficient to fill the smaller tubes and alveoli and cause consolidation.

Of those particles which are finally lodged on the alveolar walls some become incorporated with the epithelial cells, to remain there permanently or to be transferred to the subjacent lymph spaces. Others reach the lymphatic channels by insinuating themselves between the epithelial cells, which are loosened and elevated by the rapid growth of new cells that is excited by the irritating presence of the foreign bodies, and from here they are carried in by cellular elements which are probably migrated white blood corpuscles.

From this point the distribution follows the course of the lymph channels, more especially in the sheaths of the bronchial tubes and smaller branches of the pulmonary artery, and in the interlobular septa. Many of the pigment granules are arrested along the course of the lymphatic vessels. They either become clogged in the lumen of the vessel or some sharp point pierces the thin wall and they are then embedded there or pass into the connective-tissue spaces. At many points they become aggregated in minute nodules which completely block the vessels and arrest the lymph current. When this condition is very extensive, nutrition of the pulmonary tissue may be seriously affected.

Notwithstanding the continual permanent deposition of the dust particles along the lymphatics, proportionately large amounts pass through these vessels and finally become deposited in the bronchial glands. Only in rare instances do particles find their way to the cervical or abdominal lymphatics.

All the pulmonary tissues thus become infiltrated and stained by processes which are physiological, or at least conservative, since they are directed to the removal of the irritating foreign particles from the delicate alveolar walls, where even small amounts are productive of serious inflammatory changes, to the lymphatic glands, in which considerable quantities can be stored without special detriment to the system.

The above are the processes involved in all forms of pneumonokoniosis. The morbid anatomical appearances will vary with the amount and nature of the material deposited.

Post-mortem examinations show a moderate amount of carbonaceous and other extraneous pigment deposits in the lungs of all adults, more especially of such as have resided in cities. In the lighter grades the surface of the lung is uniformly mottled and striated in black or deep brown, the striæ marking out the interlobular septa and the pigmented spots indicating concretions in the lymph vessels or areas of lymphatic plexuses.

As the pigment deposits increase the color deepens, until in the higher grades of anthracosis the lung is of a uniform coal-black color, while the pleura presents a bluish-black and semi-transparent appearance, owing to the implication of only the deeper layers in the pigmentation. On passing the fingers over the surface distinct hard nodules may be detected, either causing slight elevations or lying more deeply embedded in the substance of the lung. The lungs are increased in size, often markedly so; they have everywhere a firm resistance, which in some portions amounts to an almost stony hardness. They crepitate but little, and their specific gravity is in many cases raised above 1.000.

On section the cut surface presents the same variations in color, from a fine outlining of the lymph courses to a uniform black. Here the nodules and concretions become more apparent, varying in size from the most minute appreciable point to others the size of a pea. On pressing the lung a more or less deeply stained fluid exudes, from which the pigment matter may be obtained and its nature determined. The concretions when isolated resemble minute bits of coal.

Upon microscopic examination, in the earlier stages, the lines of pigmentation are seen to follow very closely the distribution of the lymphatic vessels. Later, the pigment granules may be detected in the alveolar epithelium and free among the connective-tissue fibres. In many instances the nature of the pigment matter can thus be recognized.

The changes in the bronchial glands are equally varied in extent. As increasing amounts of inorganic matter become arrested in their meshes, gradual absorption of the glandular substance takes place, while the glands themselves become enlarged and indurated, until in extreme cases they may reach the size of walnuts, and on section present the appearance of encapsulated, compact masses of fine coal. When other pigments than carbon

are deposited within the lung, the only variation in the anatomical appearances will be in the color. The oxide of iron gives a brown or reddish color, and the metals generally give a lighter tint. Silica and the various clays cause gray tints, which are often darkened, however, by admixture with carbon elements. The ease with which the various forms of dust penetrate the tissues will determine largely the proportionate distribution of the pigmentation. In anthracosis the bronchial glands are quickly affected. The same is true of some of the metallic dusts and silica in some forms. The various clays pass but slowly into the tissues, and the pigmentation will therefore be more strongly marked in the interlobular septa near the alveoli.

It is to be remembered in this connection that high grades of pulmonary pigmentation, with quite decided enlargement, induration, and staining of the bronchial glands, may be due to processes entirely independent of inhaled matters, and that in some instances it is not possible to distinguish anthracotic from melanotic pigment derived from the blood.

An exception must be made to the above description as applied to byssinosis and allied forms of dust. When inorganic matters are mixed with the inhaled organic fibres, as happens with dirty cotton, they become separated by mixture with the bronchial secretions and afterward pass into the lung tissue as already described.

The organic fibres, however, cannot pass through the alveolar wall, and, indeed, they seldom are carried thus deeply into the lung, but are gradually softened in the mucous secretions, become rolled into slate-colored gelatinous masses, and are thrown off in the expectoration.

The above constitute those changes which can strictly be called pneumonokoniosis. They are seldom present alone, however, and in the higher grades they always induce secondary changes.

Whatever the nature of the dust inhaled, the secondary processes excited by reason of its chemical or mechanical irritating qualities are identical in character; they vary only in intensity and in the order and proportion of their development.

Dust deposits occur in the lung in a large proportion of cases intermittently and with extreme slowness, few artisans working over ten, and miners only eight, hours out of the twenty-four. The consequent diseases are, with equal frequency, chronic inflammations and degenerations.

The one most constantly and earliest developed is bronchitis. It presents no peculiarities beyond a tendency to the production of an exceedingly viscid mucus. The mucous membrane at first is thickened; later, it is atrophied, and may be ulcerated or contain ecchymoses.

Closely following the bronchial changes, and coincident with the passage of the dust elements into the interlobular tissue, there occurs a low grade of productive inflammation, characterized by cellular infiltration and connective-tissue hyperplasia.

These fibroid changes at first produce thickening of the interlobular and alveolar septa, but as the new tissue becomes organized and begins to contract, pulmonary nutrition is decreased, the septa atrophy and finally are absorbed, and the lung tissue gives place at various points to firm, tough bands and masses of the new growth. Adjacent lobules, which have escaped, in part, the fibroid processes, become distended, thus developing a compensatory emphysema. Similar fibroid changes about the tubes exert traction, which, in connection with softening and ulceration of the tubes, causes bronchial dilatations or bronchiectasic cavities. These bands of new tissue may be several inches in length, and are at times an inch or more in thickness. They have no definite outline, but merge gradually into the surrounding tissues. Small fibrous bands pass from the pulmonary tissue to the deeper layers of the pleura, where a similar fibroid condition exists. Such changes are best marked along the anterior borders of the lungs, and over such areas the pleura may be thickened by organization of surface exudation as well as by the subpleural changes.

The contracting fibroid growth not only induces atrophy and absorption by compressing the capillaries, but causes similar obstruction to the circulation in the larger pulmonary vessels and lymphatics, a condition which in the lymph vessels is augmented by pigment concretions and glandular infiltration.

As a result, local congestion, exudation, œdema, or even extravasation may occur, and in extreme cases infarctions, abscess, and gangrene are present. These, by rupture or sloughing, form large ragged cavities, whose walls continue to secrete offensive pus, which appears in the expectoration mingled with gangrenous shreds of pulmonary tissue.

Chronic bronchitis and fibroid phthisis are thus seen to be the necessary complications of chronic pneumonokoniosis, to which lobular pneumonia and compensatory or atrophic emphysema are often added. Such a lung would seem to furnish a fertile soil for the growth of tubercle bacilli, and it is a noteworthy fact that tuberculous processes are developed late if at all.

It has been questioned whether acute inflammatory processes, with exudation and cellular proliferation, are ever excited within the alveolar cavities by the inhalation of dust. Recently such a condition has been described as affecting grain-shovellers, in which the etiological element was unquestionable. The lungs are never seen until the process is well advanced. Then the pleura is found to be adherent, deeply congested, red, thickened, and covered with a false membrane of plastic exudation. Serous effusion into the pleural cavity is rare. The lung itself is dark red, with occasional points of extravasation just beneath the pleura.

Consolidation is most marked posteriorly, and is due to both vascular engorgement with serous exudation, and inflammatory products within the alveoli and smaller bronchioles. The consolidated portion is soft and pulpy, breaking down easily under pressure. On section it presents a deep red or gray color, according to the stage, and from the cut surface there flows a frothy, bloody, or purulent fluid. Small infarctions and abscesses may be present in the later stages.

Under the microscope the alveoli are seen to be filled with exudative products and granular or broken-down cellular elements. Rarely, a bit of the beard from the grain may be recognized.

The pathological processes, which affect both lungs, appear to be a mixture, in varying proportions, of hypostatic and broncho-pneumonia, accompanied by circumscribed areas of plastic pleurisy. Changes in the liver and kidney are functional rather than organic.

Etiology.—Predisposing conditions: There is no condition which strictly can be considered as predisposing to inhalation of dust, beyond the anatomical conformation of the nasal and respiratory passages, except the habit of mouth-breathing.

Workmen who habitually inhale through the mouth, or whose occupation compels them to take sudden, deep inspirations often suffer more in a dusty atmosphere than those who, though working under the same conditions, breathe through the nostrils and inhale more gently.

Very many conditions, however, under which artisans labor exert a strong influence in increasing the extent and severity of the diseases consequent upon dust inhalations.

Imperfect ventilation of mines or workshops and overcrowding of operatives result in a vitiated air which of itself tends to pulmonary congestion and inflammation. Under such circumstances not only is the bronchial mucous membrane more susceptible to irritation, but the amount of dust deposited is relatively larger.

Again, constrained positions, as in mining, or occupations requiring but little muscular effort, as in metal-polishing, not only tend to favor the rapid accumulation of inhaled matters and lessen the ease with which they are expectorated, but they seriously interfere with pulmonary nutrition, and so decrease the power of resisting deleterious influences.

All inherited vices of constitution, more especially the

lymphatic diathesis, enervating habits of life, the use of alcohol, and excesses of all kinds, lower vitality and predispose to pulmonary disease when pneumonokoniosis or any other irritant is the exciting cause.

Exciting Causes.—Any form of inorganic dust, and very many organic products, when persistently inhaled will produce various degrees of pneumonokoniosis, which in turn may be the direct cause of any of the secondary diseases.

It were superfluous, then, to attempt to mention all the exciting causes. Among the more common avocations, however, in which laborers are exposed for prolonged periods to a dusty atmosphere are mining of the various minerals, and the handling of anthracite or bituminous coal in transit to its point of consumption; charcoal-grinders and carriers, moulders and those who clean castings, metal- and glass-polishers, stone-masons and plasterers, chimney-sweeps and laborers who tear down old buildings, potters and grinders on various forms of stone, bakers and pastry cooks, gilders and gold or tin-foil beaters, workers in mother-of-pearl and lead, jewel- and glass-cutters, file-cutters, millers, tobacco-workers, factory operatives, grain-shovellers, etc., through a still longer list, all suffer from inhaling the peculiar dust produced by the nature of their avocations, and develop varying grades of pneumonokoniosis.

Recent years have seen very great improvements, however, in the measures taken to protect operatives, particularly polishers and grinders, and a corresponding decrease in this form of disease.

The extent and character of the inflammatory changes, together with the order and rapidity of their development, will depend upon several factors.

1. The amount and character of the exposure. Other things being equal, the secondary conditions will stand in a direct ratio, as to their extent, with the amount of dust deposited. The rapidity with which this deposition takes place affects very decidedly the nature and severity of the subsequent disease. When artisans breathe a dusty air for only a few hours each day, as is almost invariably the case, the lungs soon accommodate themselves to the new conditions, and the usual processes of absorption are sufficient practically to clear the alveoli of foreign matters during the hours of non-exposure. There will be an acute bronchitis for a short time, but it soon subsides and passes into a chronic form, which is unimportant and causes little trouble to the patient. In such cases the principal changes will be fibroid in character and may not become prominent for years, the rapidity of their development depending upon conditions yet to be considered.

The results are very different when dust is inhaled continuously for a long period.

In handling grain the shovellers not only labor in confined places, as the holds of canal boats, where there is absolutely no ventilation, but they work without intermission for days. The gang bosses admit that the labor is sometimes continuous for thirty-six hours, while the workmen claim that they are often employed for five and six days, with intermissions of only a few moments for food and rest. Taking an average as the truth, it gives three and four days as the probable length of time during which every respiration bears to the lung large quantities of an exceedingly irritating dust. Under such conditions the absorptive processes are inadequate for its removal, and the tubes become filled with the irritant. The resulting inflammations are acute exudative processes. As before, bronchitis appears first, usually following the first exposure, but later, similar exposure induces the pseudo-pneumonic changes already described.

2. The nature of the inhaled dust, as regards its penetrating power and chemical qualities.

The most penetrating, as well as the most irritating, forms of dust are the siliceous, as the particles have exceedingly sharp edges and fine points. Similarly, mineral coal passes into the tissues more easily than charcoal, but both are only slightly irritating, owing to their chemical properties, as compared with other forms of dust. True anthracosis often reaches a condition of almost complete solidification without inducing any extensive fibroid change. Although pulmonary diseases are much more frequent among miners than in the community at large, the percentage of phthisis cases to the total number of sick, among this class, is lower than in any other class of dust workers (Hirt's statistics).

Various clay dusts pass into the lung but slowly, being deposited more thickly about the alveoli; yet they possess specially irritating properties and speedily cause severe disease. Metallic dusts also stand high in the list of irritating matters.

Tobacco dust passes into the lungs quite freely, but the resulting diseases are due to its constitutional effects rather than its locally irritant properties.

The frequency with which pneumonokoniosis is an etiological factor in pulmonary phthisis among the laboring classes in large cities may be fairly determined by the following list, taken from one thousand consecutive cases of pulmonary tuberculosis entered upon the dispensary records of the University Medical College and Bellevue Hospital, only those being given here in which dust inhalation was a possible factor. It is but fair to state, however, that probably only a small percentage of the 311 cases classed as laborers were engaged in handling coal. The list includes only males.

Printers	48	Machinists	14
Carpenters	45	Bakers	12
Masons	39	Moulders	10
Painters	28	Hatters	7
Tobacco-workers	24	Wood-turners	6
Factory hands	23	Glass-workers	4
Stonecutters	23	Millers	4
Iron-workers	20	Weavers	3
Blacksmiths	18	Gold-beater	1
Brass-workers	15	Dyer	1
Total			345

The above cases, together with those which should be taken from the class of laborers, form nearly forty per cent. in which inhalation of dust can fairly be regarded as having predisposed to the phthisical processes.

Symptoms.—Chronic pneumonokoniosis presents but few symptoms. So long as the patient continues his occupation the bronchial secretions will contain pigment matters. Cough is an early and persistent symptom. It may be due to either bronchitis or pressure of an enlarged bronchial gland. Dyspnœa is often a prominent symptom even when no appreciable inflammatory conditions are present, and appears to depend upon deficient oxygenation caused by abundant pigment deposit. Other symptoms will depend upon the secondary diseases. Subacute and chronic bronchitis will afford the usual subjective and physical signs. In some cases the prominent symptoms will be those of fibroid phthisis, with compensatory or atrophic emphysema. In others the asthmatic element is prominent, and in all the physical signs of pleurisy will be present at an early stage of the disease. Inflammation or enlargement of the bronchial glands (*q. v.*) will cause characteristic pressure symptoms. If tuberculous infection occurs it will soon be indicated by rise of temperature, hectic, rapid exhaustion, and hæmoptysis.

The phthisis of anthracosis, however, is seldom tuberculous or rapidly progressive, but tends to abatement or even recovery when the exciting cause is removed.

The acute processes which ensue upon the prolonged inhalation of specially irritating dusts are the most severe in the so-called elevator disease.[1]

The earliest attacks are in the form of acute bronchitis with profuse muco-purulent expectoration, unattended by fever or other constitutional symptoms. Within a year or two, however, when from repeated attacks of bronchitis the lungs are more susceptible to irritation, some especially prolonged period of exposure excites an inflammatory process resembling acute broncho-pneumonia.

The more decided symptoms are preceded for a day or two by some bronchial irritation, cough, and expectoration. Distinct onset of the disease is marked by a light

chill, and a rapid rise of temperature to 101° F. in mild, or 105° to 106° F. in severe cases, with an average of 103° F. The pulse is frequent and feeble, and the heart's action tumultuous. The face is flushed, but the skin remains moist. Delirium is frequent in both the sthenic and the asthenic cases. The cough is increased, and the sputa become thick, tenacious, rusty, or hemorrhagic; later they are purulent, with an exceedingly offensive odor.

On physical examination both lungs are found to be affected. There is partial consolidation in the posterior and lower portions of the lungs, with evidences of alveolar and bronchial exudation such as are usually present in hypostatic pneumonia. The physical signs of a plastic pleurisy are often present over the consolidated portion.

The disease runs a prolonged course of from ten days to two weeks with sthenic symptoms, and convalescence may not be complete for two or three months.

Many cases pass into a condition presenting all the rational signs of phthisis, with hectic, night sweats, and rapid emaciation, but without the physical evidences of tuberculous infection.

In connection with the pulmonary processes there may be renal and hepatic complications, and general disturbances in the digestive functions.

Diagnosis.—The recognition of pneumonokoniosis, either as a condition *per se* or as a causative factor in other pulmonary diseases, depends entirely upon the history of the case and the detection of pigment in the sputa.

Prognosis.—The prognosis depends primarily upon the possibility of removing the exciting cause, and the extent and character of the secondary changes.

When the subject cannot or will not give up his occupation, the duration of the disease will depend upon the general habits and constitution of the patient, and upon those factors which are more fully discussed under Etiology.

Treatment.—Prophylaxis is the only practical line of treatment. Since men must work at dusty avocations, means should be devised for preventing the inhalation of the dust particles. In those trades in which dust is formed at a single point, as in polishing, glass-cutting, wood-turning, etc., some form of blower or aspirator which will entirely remove the dust is the most effective protection. When, however, the dust is evenly diffused, as in tobacco factories and iron foundries, any amount of ventilation which would successfully remove the dust will become a source of danger from cold and draughts. In such cases respirators, although more or less clumsy and disagreeable, are exceedingly valuable. In all cases they possess the advantages of being under the control of the operative and always available, while ventilators, blowers, and aspirators must often be wrung from soulless corporations. A cheap respirator, and one which not only has the advantage of being easily cleaned, but is also very efficacious, may be made from a fine flat sponge.

Treatment of the secondary complicating chronic diseases presents no peculiarities.

For the acute broncho-pneumonia it is generally tonic, stimulant, and symptomatic. *Charles E. Quimby.*

[1] Rochester: Buffalo Medical and Surgical Journal, 1879.

LUNGS, DISEASES OF: PNEUMOTHORAX.—Definition.—By pneumothorax is meant the presence of air in the pleural cavity. In the great majority of cases a collection of fluid rapidly follows, either serous or purulent, and termed hydropneumothorax and pyopneumothorax respectively.

Etiology.—According to West and other writers, about ninety per cent. of cases of pneumothorax are due to the rupture of a tuberculous focus on the surface of the lung, allowing of the entry of air to the pleural cavity.

The disease usually occurs on the side in which the tuberculous lesions are most advanced; it occurs with greater relative frequency in acute cases of tuberculosis, and when occurring in chronic cases febrile symptoms are often present, indicating an exacerbation of the disease. Weil found that twenty-two out of forty-six cases were in subjects of acute tuberculosis, although it is well recognized that this type of the disease is rare compared with the chronic form. The period at which it is most common is during the first year, thirty of Weil's forty-six cases occurring within this time.

Both Douglas Powell and West agree that the condition occurs in about five per cent. of all cases of pulmonary tuberculosis.

It is more particularly in cases of rapidly forming small superficial cavities, lined by friable caseous tissue, that rupture is apt to occur. In more chronic conditions there is less danger of rupture taking place, owing not only to the less friable structure, but also to the presence of pleural adhesions.

Pneumothorax may occur early in the course of tuberculosis and even be the first sign of disease, but it is more common in the well-developed or advanced cases. In Weil's series only eleven of the forty-six cases occurred in the early stages of the malady.

Of late years a considerable number of cases of pneumothorax, occurring in apparently healthy persons, have been reported. It is highly probable that most of these cases are really due to a latent tuberculous focus. This view is borne out by cases in which a subsequent post-mortem examination has been made, and, as West points out, in many of these cases the pneumothorax has come on during rest or sleep, a circumstance which renders it highly improbable that the lung was in a healthy condition.

Of the ten per cent. due to other causes than tuberculosis, empyema rupturing into a bronchus is the most important. It is, however, only a small proportion of such cases that are followed by pneumothorax. Considering the fact that there is a negative pressure in the pleural cavity, it is remarkable how seldom pneumothorax is observed in such cases or when the pleura is torn by a fractured rib. West regards the absence of pneumothorax as being due to the cohesion between the two layers of the pleura, and supports his view by some very ingenious experiments. By making a double membrane of a piece of stomach, placing the serous surfaces in apposition, and then attaching the double layer to a bell-jar, connected by its other end to an air-pump, it was found that the two layers of membrane remained in apposition, unless there was a considerable diminution of air in the bell-jar. Gangrenous areas in the lung resulting from inhalation-pneumonia, putrid bronchitis, or other causes, occasionally terminate in pneumothorax.

Traumatism is an occasional cause. Penetrating wounds of the chest wall, such as stabs or gunshot injuries, severe crushing injuries, fracturing ribs and tearing the lung, or even rupture of the lung without fracture of ribs, are all recognized causes of this condition. Owing, however, to the force of cohesion, already referred to, it is only in a minority of such cases that pneumothorax actually occurs.

Rupture of an emphysematous bleb has been noted in a few instances, and a series of cases has been recently reported by Zahn (*Virchow's Archiv*, cxxiii., p. 197). Chauffard has also recorded a case presumably due to this cause, tuberculosis being excluded by the tuberculin test.

Holmes records a case of pneumothorax setting in some days after injury, and regards the condition as first of all an interstitial emphysema, and thence extending to the surface of the lung and rupturing into the pleura.

Hemorrhagic infarcts may break down and give rise to pneumothorax; Hale White attributes the pneumothorax observed in rare cases of typhoid to this mechanism.

Wilks and Moxon noted the occurrence of two cases of pneumothorax after tracheotomy; Money also found two instances in twenty-eight cases of tracheotomy in which it was specially looked for (Med.-Chir. Soc., lxvii., 1884).

It seems probable that air passes beneath the deep fascia of the neck to the mediastinum, and thence ruptures into the pleural cavity. This view is strongly borne out by Champney's experiments on dead infants, in whom tracheotomy and artificial respiration had been performed, air

being drawn into the mediastinum and thence passing to the pleura.

An extremely rare form of pneumothorax has been recently proved to result from the action of gas-forming bacteria, particularly the bacillus capsulatus aërogenes. Cases of this nature have been recorded by Levy and A. G. Nicholls.

Communication between one of the hollow abdominal viscera and the pleura is occasionally set up by suppurative processes, or by the ulceration of malignant growths, especially of the colon or stomach. Ulcers of the œsophagus, simple or malignant, occasionally open into the pleura and allow of the entry of air. A remarkable case has been recorded by Laache in which a fish bone, accidentally swallowed, induced a pneumothorax by penetrating the œsophageal wall. The condition is most frequent between the ages of twenty and thirty, thus corresponding with the greater incidence of tuberculosis in young adults. It is again more common in the male than in the female sex, and is about twice as frequent on the left as on the right side.

Morbid Anatomy.—In the majority of cases the whole pleural cavity is affected, with perhaps the exception of a few adhesions at the apex. To determine the presence of pneumothorax a small opening in the thorax may be made; a rush of escaping air is a sure sign of the condition, but this occurs only with a positive pressure. Fowler advises the removal of the intercostal muscles over one or more interspaces. If the parietal pleura is not thickened, the visceral layer can be seen through it; if it is, a small opening is made and there is no difficulty in determining if the two pleural layers are separated by an air space. The lung is collapsed and flattened against the spine, while the diaphragm with the liver and spleen is depressed and the mediastinum displaced to the opposite side. The opening in the lung is usually of small size, and if not apparent is readily discovered by blowing air through the bronchus, the lung being held under water. Exceptionally the opening is large and may attain the size of 2 or 3 cm. In most instances the perforation is situated in the upper lobe, more particularly its mid-lateral aspect, and in a few instances two or more openings are present. The opening in the pleura is usually found at autopsy, even after a period of weeks or months. Exceptionally it closes, and it has even been found obliterated in the course of a few days.

The condition of the pleura varies considerably. In a few instances, when death occurs in a few hours, it is normal, but most commonly it becomes infected and is covered by a layer of lymph of varying thickness. Although fluid is absent in a few cases, there is usually a sero-purulent or purulent exudate, varying in quantity from 100 c.c. to several litres. In traumatic cases there is pure blood. In 30 cases examined post mortem, 11 were purulent, 17 sero-fibrinous, 1 hemorrhagic, and 1 putrid (Weil). Rose, however, found a preponderance of purulent cases, 10 out of 19 being of this character, 7 serous, and in 2 fluid was absent.

Symptoms.—The onset is abrupt, and usually marked by intense catching pain in the side together with dyspnœa. Troublesome and incessant cough is sometimes present, and is usually the result rather than the cause of the malady. The symptoms may come on spontaneously or even during sleep, but are sometimes the result of cough or other straining effort. Occasionally a feeling of something giving way is experienced at the onset.

The pain is often of an extremely violent character. It is increased by the respiratory movements, and is often accompanied by fainting sensations, profuse sweating, and a small, thready pulse. Giddiness, syncopal attacks, and even loss of consciousness are occasionally seen.

Dyspnœa sets in with the pain. There is a feeling of oppression and breathlessness, while the respirations are short and increased in rate, sometimes rising to 60 or 80 to the minute. There is frequently an increasing dyspnœa owing to increasing pressure of air admitted by a valvular opening. The face is anxious and pallid and there are signs of cyanosis in the lips, cheeks, and extremities.

The onset is not always so dramatic in character. The initial pain and dyspnœa may be less severe and in a few instances entirely absent.

Breathlessness is usually marked on exertion, and may increase as fluid collects in the thorax. In advanced tuberculosis the onset may be latent, owing either to obliteration of a large part of the sac from adhesions, or to extensive disease of the lung having destroyed its respiratory function.

In rare instances double pneumothorax has occurred, and Rose has collected fourteen instances from the literature (Rose, *Deut. med. Woch.*, 1899). It is inevitably immediately or rapidly fatal, although in one instance the patient survived for a week. Recurrence of pneumothorax has been recorded by West and others.

With severe dyspnœa the patient is sometimes obliged to assume a raised position in bed, often lying obliquely on the healthy side, a posture which affords some relief to pain.

The temperature often falls at the onset, especially when the symptoms of shock are severe. Subsequently its course is influenced by the secondary pleurisy, or by the underlying tuberculosis.

An accumulation of fluid follows rapidly at the onset in by far the greater number of cases, although in a few instances it is entirely absent.

The presence of fluid depends on infection of the pleura, and in a number of those rare instances resulting from emphysema, in which infection is least likely to occur, its absence has been noted.

With serous fluid the quantity may remain moderate in amount, but more often, if the patient survive for any length of time, it gradually increases in quantity and requires removal owing to increasing dyspnœa. This procedure in chronic cases may be repeated a number of times as the exigencies of the case require. During the intervals there may be periods of comparative health, and, should the fistula heal, the lung expands and cure results. Unfortunately, it is only in rare instances that such a fortunate termination is attained.

When the fluid is purulent the course is more rapid, death resulting from sepsis and exhaustion. In a few cases the symptoms become quiescent and the patient can get about and attend to light duties.

Hæmopneumothorax is seen particularly in traumatic cases. In a recent case of Pitt's a fatal issue resulted from the rupture of an emphysematous bleb with probable tearing of pleural adhesions.

Physical Signs.—These are very striking and in most instances unmistakable. Inspection reveals a marked fulness of the affected side of the chest, seldom seen to the same extent in other conditions. The infraclavicular fossa and mammary region are distended and the intercostal spaces are full and wide, while expansion is entirely absent or greatly diminished. The extraordinary muscles of respiration are called into play, the veins of the neck are full and distended, and a transient œdema of the hand on the affected side has been occasionally seen.

Palpation reveals marked diminution or absence of fremitus, a point of some importance in the distinction from a large cavity. Although the liver or spleen is depressed, according to the side affected, the organ is seldom felt below the costal border.

Percussion gives a full, deep, resonant, and drum-like note, often having a tympanitic or even an amphoric character, and extending beyond the normal limits of the lung, particularly anteriorly, where fluid is less likely to be present. This note extends to the opposite sternal border; on the right side it may reach the costal border, and on the left side it replaces the area of cardiac dulness. Posteriorly a similar note is heard, becoming dull on reaching the level of fluid. In some instances, Osler states that a dull note is present over the lung, due to greatly increased pleural tension. This is certainly rare, and both Fowler and West state they have never heard it. The level of dulness at the base alters readily with

change of posture, and much more noticeably than in pleurisy. Owing to the large space at the base of the thorax occasioned by the descent of the diaphragm, a large collection of fluid may be present with a very limited area of dulness.

Auscultation reveals greatly enfeebled or absence of respiratory sounds, or there is a marked amphoric or metallic character. The amphoric character may be heard over only a small area, and may be present at one examination and disappear at the next. It is heard both with closed and with open fistulæ, and is consequently not due to air entering and leaving the pleura, but rather to a modification of the sound generated at the glottis and transmitted through an air-containing chamber.

A series of signs, known as metallic phenomena, are very characteristic. Râles when present have a tinkling metallic quality, and the voice sounds and cough have a hollow echoing character. The coin test, brought out by percussing anteriorly with two coins, one of which is used as a pleximeter, and at the same time listening with the ear or stethoscope on the back, yields a ringing and metallic sound.

Hippocratic succussion is the splashing sound induced by shaking the patient. In order to hear this sound it is usually necessary to place the ear against the chest, but it is sometimes heard at a short distance from the patient, and is distinctly heard by the affected individual. This sound is present only with air and fluid in the thoracic cavity and is never heard in an ordinary pleurisy.

Marked displacement of the organs is important evidence of the disease. The heart is displaced toward the opposite side, the organ being seen and felt to the right of the sternum with left-sided disease, and beyond the left nipple when the right lung is perforated. The liver and spleen are displaced downward, but can seldom be felt below the costal border.

Diagnosis.—The physical signs of a well-marked case are so distinctive that their significance is usually obvious. Fulness and immobility of one side, the altered percussion note, the feeble and amphoric breathing, metallic phenomena, succussion, and cardiac displacement make up a very characteristic combination of physical signs.

A sudden onset with dyspnœa and pain frequently suggests the nature of the disease, especially when evidence of previous pulmonary tuberculosis is obtained. Localized cases are readily overlooked and here the diagnosis rests chiefly on the physical signs. Very exceptionally a large quantity of fluid may mask the presence of air, which is recognized only after aspiration and withdrawal of fluid. Large cavities, particularly those rare cases of almost total excavation of the lung, sometimes cause difficulty in diagnosis. The percussion resonance, however, is often dull, the vocal resonance is increased rather than diminished, the coin sound is heard only in rare instances, there is flattening rather than fulness of the affected side, the heart is not displaced, and succussion is very seldom present.

After severe injuries rupture of the diaphragm with the escape of the abdominal viscera into the thorax may precisely simulate the signs of pneumothorax and render a correct diagnosis impossible. In pyopneumothorax subphrenicus tympany, metallic phenomena, and succussion may all be present. The tympanitic note is, however, present in the lower costal region, and is limited above by a line curved upward, representing the line of the diaphragm. Pulmonary resonance, often of tympanitic character, but differing in tone from that from the cavity below, is present at the upper part of the thorax, while vesicular breathing is also audible at the apex.

A history of gastric ulcer or of other abdominal disease is also suggestive of a subdiaphragmatic origin.

Rupture of a subdiaphragmatic abscess into the pleural cavity renders recognition of the primary condition difficult or impossible. In one such case under my care the difficulty was still further increased by the lower part of the pleura, which communicated with a subdiaphragmatic cavity, being shut off by a circular ring of adhesion.

Prognosis.—The immediate prognosis is based on the degree of dyspnœa and the characters of the pulse. According to West the mortality is about seventy per cent. Saussier's figures give the higher rate of ninety per cent. The greater number of deaths occur within the first few days of the disease, nearly one-half dying within the first week. Of the cases fatal during the first fortnight, one-third succumbed on the first day (West: Med. Soc. Trans., vol. xxi., *Lancet*, 1897).

Death usually results from suffocation and may occur within a few minutes of the onset. Rare cases have been recorded as proving immediately fatal from shock. When the patient survives the danger of the earlier stage, the exhaustion resulting from empyema or from advancing tuberculous disease frequently proves eventually fatal. It has been estimated that from ten to twenty per cent. of the cases terminate in recovery.

Among conditions which render the outlook favorable are good general strength, an absence of disease in the opposite lung, and the failure of fluid to collect in the affected pleura. The cause of the disease must be taken into consideration. Tuberculous cases are usually the most serious, while those resulting from empyema or injury frequently run a more favorable course.

Treatment.—The immediate treatment of pneumothorax consists in the hypodermic injection of morphine. By this measure pain, cough, and dyspnœa are alleviated and the anxiety and distress of the patient greatly lessened. Local applications of hot fomentations or poultices will also give some relief.

To combat shock and feeble cardiac action hypodermics of ether are useful, and they may be followed by the administration of strychnine and alcohol. The inhalation of oxygen has also proved of benefit.

When dyspnœa is a marked symptom, withdrawal of air through a small needle may be tried. Owing to the fistula in the lung remaining open this usually proves of only temporary benefit, and in such instances the needle may be left in for some days, covered with an aseptic dressing. There is sometimes an escape of air into the subcutaneous tissues along the track of the needle, and in withdrawing it pressure should be kept up for a few minutes over the site of puncture to avoid this accident. When fluid collects, an exploratory puncture should be made to determine its character. If serous it may be removed when the quantity is so considerable as to cause dyspnœa.

When pus is present, considerable difference of opinion exists as to the best method of procedure. When it is due to trauma or empyema there can be no doubt that free draining should be established.

In tuberculous cases, when the symptoms are not urgent, a waiting policy is often more satisfactory than active interference. If, however, the quantity of fluid is large and dyspnœa becomes marked, something must be done for its relief. Aspiration may be tried first, and should the fluid rapidly collect, a free incision and drainage should be established. Excellent results have followed in a few cases, and it is surprising in these how the lung may expand and the cavity gradually close. When the pus is fetid free evacuation is imperative, offering as it does the only chance of improvement.

Frederick G. Finley.

LUNGS, DISEASES OF: SYPHILIS. See *Syphilis*.

LUNGS, DISEASES OF: TUBERCULOSIS.—Etiology.—There are two factors in the causation of pulmonary tuberculosis which have a practical bearing on the subject, namely, the tubercle bacillus and the resisting power of the lung tissue with which it comes in contact. The bacilli are essentially the cause, and, if in sufficient numbers, of marked virulence, and properly introduced, the result would be tuberculosis in practically every case. Fortunately these conditions rarely obtain, and so the resisting power of the individual becomes the more important clinical element as compared with the bacilli to which we are nearly all exposed. How the

bacilli enter the body is still an open question, but authorities are generally agreed that the main channel is viâ the respiratory tract, less commonly through the blood and lymph channels, the skin, alimentary canal, etc. Direct hereditary transmission can occur, but is rare unless we grant that in many cases it remains latent for a very long time. Of 15,400 calves killed at the Berlin abattoir there were only 4 instances of tuberculosis (Osler). Hereditary predisposition cannot be doubted. In 1,000 cases collected by Dr. Theodore Williams we find that 12 per cent. showed tuberculosis in the parents and 48 per cent. in some member of the family. House infection is also a cause, especially if the bacilli are not exposed to light and air and are allowed to be scattered as dust throughout the rooms. There is some evidence, necessarily incomplete, which shows that direct transmission from man to wife or mother to child has occurred where carelessness concerning the disposal of the sputa existed. The contagiousness of the disease has, however, of late, been overrated and has caused undue alarm and much inhumane separation of relatives. It is a wonder that the coincidences of one case following another have not been more frequent when we consider the prevalence of the disease.

Among the predisposing causes may be mentioned a run-down condition which follows some of the acute infectious diseases, such as measles, typhoid, and influenza, also frequent pregnancies, prolonged lactation, excessive worry, and diabetes. Improper nourishment, chronic alcoholism, lack of sunlight and fresh air, occupations which expose the lungs to injury, such as glass-blowing and stone-cutting, are also undoubted predisposing factors. Sex seems to have but little influence on the general mortality, although we find that in females the tendency is manifested earlier. Dr. Wilson Fox gives the following table from Dr. Ogle's statistics (quoted by Fowler and Godlee):

	Males.	Females.
Under 1 year	1,034	993
5 years	432	491
10 "	616	1,061
15 "	2,088	3,008
20 "	3,676	3,798
25 "	3,941	4,165
35 "	4,097	3,826
45 "	3,850	2,812
55 "	3,274	2,075
65 "	2,112	1,322
75 " and upward	730	523
All ages	2,418	2,428

Pathology.—No organ in the body undergoes such manifold changes from tuberculosis as do the lungs. Hence any classification must be either too burdensome or in part unsatisfactory. It must be remembered that clinically these forms may be associated. Although the general pathology of tuberculosis is described more fully elsewhere, we must pay some brief attention to its effects in the lungs along with the different clinical pictures.

Acute miliary tuberculosis is caused by an invasion of the tubercle bacilli into various organs—the lungs, pia mater, lymph nodes, spleen, kidney, bone marrow, etc. This invasion may be primary, but more often is due to some older focus of tuberculous inflammation not always discovered. In the lungs we find a general distribution of miliary tubercles which are softer or harder, larger or smaller, gray or yellow, in accordance with the acuteness of the process. They are distributed in the parenchyma of the lung, in the septa, in the walls of the bronchi and blood-vessels, and on the pulmonary pleuræ.

These tubercles may quite replace the lung tissue, or still leave visible the outlines of the air vesicles. If the walls of the bronchioles or air passages become infiltrated the adjacent air vesicles soon become affected. These nodules caseate in the centre as time goes on. The lungs are increased in size and are hyperæmic, while the bronchi are congested and coated with mucus. The bronchial glands are swollen and may caseate. The other organs show changes described elsewhere, and of course greatly modify the clinical picture.

The onset of the disease varies; it is generally a gradual one but sometimes is very acute. The patient becomes languid, feels ill, suffers from anorexia, nausea, or vomiting. The tongue is coated, the bowels are generally constipated, less often diarrhœa is present. The spleen enlarges. Fever increases and assumes the remittent, intermittent, or continuously high type. Sometimes an exanthematous rash appears. Cough, cyanosis, dyspnœa, emaciation, and anæmia precede the stupor and delirium which are closely followed by death, generally within a month from the onset of the severe symptoms. The disease may be fatal within a few days or may last a few months, but probably always ends in death. If the lesions are chiefly in the lungs we have a resemblance to acute pneumonia. Pain in the side, cough, cyanosis, dyspnœa, expectoration of blood-streaked mucus, or absence of expectoration, all point to the more common disease and may easily lead us astray.

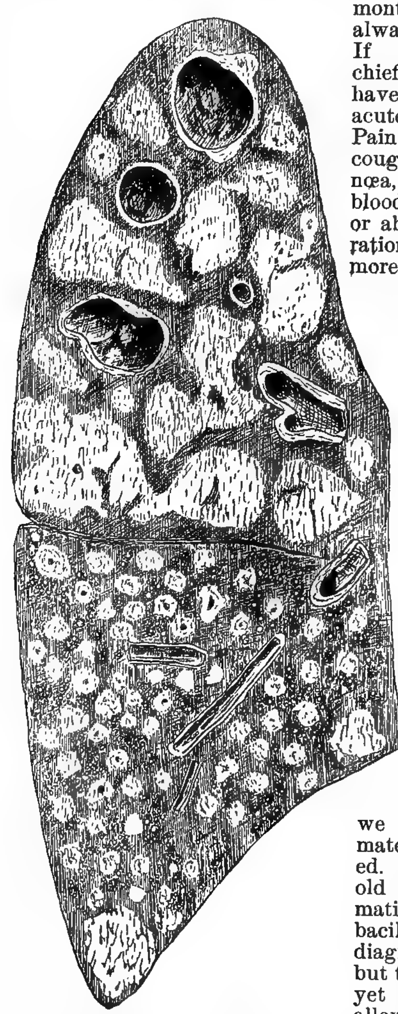

Fig. 3254.—Section of Left Lung from a Case of Rapid Pulmonary Tuberculosis. The upper lobe contains large patches of caseous pneumonia, some of which have softened, resulting in the formation of cavities. In the lower lobe smaller areas of caseation are found, generally with an occluded bronchus in the middle and, around these, miliary tubercles. The infection of the lower lobe is secondary to that of the upper. (One-half natural size.) (From W. T. Councilman.)

The physical signs are not definite and are dependent upon the old or recent consolidation, the inflamed bronchi and pleuræ. There may be no discharge of bacilli in the sputa to confirm a diagnosis. Often the accompanying meningitis (*q. v.*) makes us suspect the disease or so completely masks all other symptoms that we think the pia mater alone is affected. Sometimes an old focus of inflammation will discharge bacilli and render a diagnosis possible, but the tubercles not yet softening do not allow their escape. The special points leading to an interpretation are the cyanosis, the irregular fever, often with normal temperature in the morning, absence of marked roseola, diarrhœa, and other intestinal symptoms such as occur in typhoid fever, a pulse which is rapid in proportion to the fever and seldom dicrotic. Rarely is there any nosebleed. Tuberculosis of the choroid if detected is of course decisive.

Treatment is symptomatic. Food should be light and

Lungs.

abundant, stimulants should be given in accordance with the weakness, and baths administered for the purpose of reducing temperature. In the meningeal forms iodide of potassium and mercury with iodoform inunctions are employed. The prognosis is absolutely poor.

Subacute Miliary Tuberculosis of the Lungs.—The lesion varies in extent, being confined to a portion of one lobe, or scattered throughout both lungs. It is generally located near the apex where it may be limited, or it may extend, particularly to the apex of the other side or to the apex of the lower lobe. The tubercles are like those of the acute form, but are harder and smaller. Due to the irritation of their presence a local catarrhal bronchitis, less often a pleurisy, and rarely an exudative pneumonia, accompany the specific inflammation. The lesion may heal, remain latent, or progress. The severity of the symptoms varies with the extent of the lesion and the activity of the process. In the milder cases the patient feels languid, is ill disposed to exertion, tires readily, loses appetite, and becomes somewhat anæmic. In women amenorrhœa may attract attention first. There is a little cough, which persists, and is accompanied by a scanty expectoration of mucus. Sometimes it is only a dry cough. The bacilli may be found in the sputa of some but not all of these cases. Hæmoptyses of varying amounts are often noticed, but are also often absent. Gradually emaciation and asthenia ensue, and the disease progresses more or less rapidly, or tends to recovery, or goes on to the chronic type. Night sweats and afternoon fever increase as the disease goes on. Pain in the side, dyspnœa, on exertion especially, cyanosis, and increased expectoration may also be noticed later. The duration may be months or years, the course may be continuous or intermittent.

The physical signs are to be specially sought at the apex. They may be entirely absent or indefinite. A few localized râles, slight dulness, and incomplete expansion may be demonstrated. The vesicular murmur is changed in character, being diminished in intensity or harsher, or with prolongation of the expiration. It may assume the cogwheel type. In other words, what changes are produced are due to the loss of elasticity in the affected area, to the pleurisy, bronchitis, and the consolidation.

Chronic Miliary Tuberculosis shows changes which are modified by the chronicity of the process. The miliary tubercles are harder and may form the sole lesion. They are more apt to undergo cheesy degeneration due to the lack of blood supply and the specific poison of the bacillus. They may be scattered irregularly throughout the lungs, but the lesion is usually most marked at the apices. These tubercles coalesce and form caseous masses, which break down and form cavities. The walls of the bronchioles inflame and become partially destroyed, allowing the formation of bronchiectatic cavities. Bronchitis is present at the diseased portions. In parts there may be connective-tissue changes, involving the pleura, the lungs, or both. Portions not directly affected may show dilated air spaces. The symptoms, physical signs, etc., of this form will be considered along with chronic phthisis.

Acute Pulmonary Phthisis.—By the term "phthisis" we mean that a non-tuberculous inflammation accompanies the specific process. The acute form is often found in children and young adults with a marked tuberculous predisposition. The areas of consolidation are peribronchial and surrounded by congested portions. If the process extends rapidly, we have a general involvement of the lung tissue from the smaller areas running together. The microscope shows miliary tubercles together with the filling of the air vesicles with the products of exudation. This is noticed particularly in the walls of the bronchi and in the air spaces about them. These areas may undergo cheesy degeneration and death, with a casting off of the diseased portion, thus forming ragged cavities with but little tendency to form an organized wall. Over the affected parts the pleura is inflamed and coated with fibrin or recent adhesions. The bronchi show the changes of a catarrhal inflammation and may dilate and open into the cavities. The bronchial glands are often caseous.

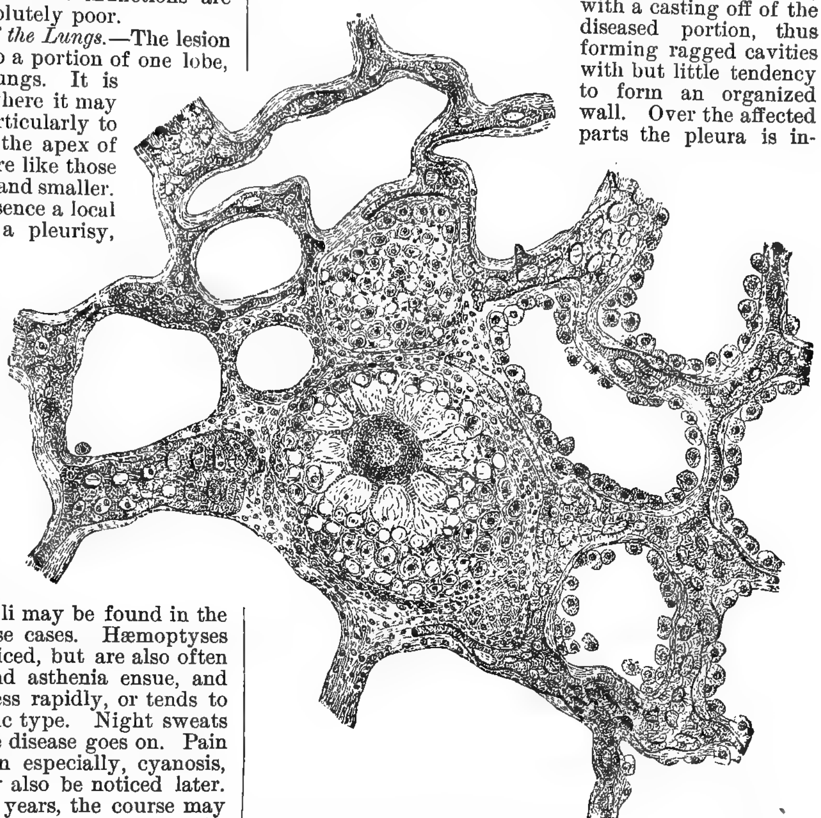

FIG. 3255.—A Miliary Tubercle Involving only Two Air Vesicles, of which the Walls are Infiltrated and the Cavities Filled with Tubercle Tissue. × 300 and reduced. (From Delafield and Prudden.)

Subacute Pulmonary Phthisis.—The process being less acute, confluence of the affected areas is less apt to occur, and time for some fibrous changes is allowed. Complete calcification or encapsulation may be noted. The area may be converted into a fibrous mass which may or may not give future trouble. The symptoms are not so acute. There is cough with expectoration which may be accompanied by blood. Tubercle bacilli are rarely absent. Anæmia, anorexia, emaciation, asthenia, fever, and night sweats are present. The cases progress steadily, intermittently, or heal, or become chronic in type. Under examination the lungs will be found to show dulness, subcrepitant râles, and increased tactile fremitus at their apices. The voice and breathing become gradually more bronchial in character, although if the bronchi are occluded we get incomplete and diminished breath sounds. The pleurisy, bronchitis, fibrous tissue, and cavities give their appropriate signs.

Chronic Phthisis.—The lesions resemble those of the more acute forms, but the chronicity of the process allows greater time for the formation of connective tissue and of large cavities. The pleuræ may be firmly adherent. The fibrous changes in the lung may extend to the point of causing the lung to appear a mass of dense tissue with cavities interspersed. The cavities may be walled by the ulcerating lung tissue or by fibrous tissue, and extending through them are cords formed by obliterated blood-

vessels and trabeculæ of lung tissue. In the vessels of the cavity wall may be seen aneurismal dilatations, from which the larger hemorrhages are apt to occur. In the fibroid form there is but little tendency toward caseation, while the connective-tissue changes are marked. If the original area is sufficiently limited, the fibrous changes may serve to encapsulate it and the lesion may cease to give trouble. When cavities occur in the fibroid form, they are more apt to have smooth walls and they secrete but little pus. They may be almost obliterated if small, never if large. The natural contraction of this fibrous tissue causes puckering and shrinkage. The heart becomes in part uncovered and drawn toward the affected side, especially if it is the left. The pleuræ are so firmly adherent that they cannot be separated. The sound parts of the lung are apt to be emphysematous.

The progress of the lesions in a case of phthisis is of practical importance. In the vast majority we find the original focus about an inch or so below the apex, sometimes nearer the anterior, sometimes nearer the posterior portion. Thence the disease spreads backward, downward, and less rapidly forward. While this process is going on in the upper lobe, the posterior part of the apex of the lower lobe of the same side becomes affected at a point readily examined when the patient draws his scapula well forward and slightly upward, thus exposing the apex of the lower lobe. Fowler has drawn attention to the clinical importance of examining this area when the signs above are doubtful. Subsequently areas of infiltration appear in the lower parts of the lobes, but separated by crepitant tissue. The extreme bases are quite free from evidences of the disease as compared to the portions described. The opposite lung is affected usually at a later date than the apex of the lower lobe, and the progress of the disease follows the same general rule. There are exceptional cases in which the bases show active disease, but generally an original focus can be demonstrated at the apex.

SYMPTOMATOLOGY.—*Acute Pulmonary Phthisis.* This form of the disease often follows other conditions, which render the lungs less resistant than usual. Measles and whooping-cough are good examples of such diseases. It may be apparently primary or may follow a limited tuberculosis of a chronic character elsewhere in the body. The onset is often acute and may resemble an acute lobar pneumonia. Chill, stitch in the side, fever, rapid pulse, cough, dyspnœa, and prostration naturally might be a group of symptoms which would be taken for the more common disease. The lungs give the signs of consolidation, dulness, bronchial breathing and voice, and crepitations. The accompanying bronchitis and pleurisy give their appropriate signs. Hæmoptyses of varying extent often usher in the disease. Unlike a pneumonia, however, the expected crisis does not occur. The patient has sweats which later are profuse. Emaciation is quite rapid and asthenia is marked. The sputa become mucopurulent and ordinarily contain tubercle bacilli after softening has begun. Elastic tissue may be demonstrated as the disease becomes advanced. Cavities form, generally at the apex, and possibly a pneumothorax may add to the distress of the disease. Death after a few weeks or a couple of months is the ordinary termination. Rarely do these patients last for as long a time as four months except in the few cases in which the disease gradually subsides and assumes the chronic type. "If the inflammation is limited to the lower lobe, the quantity of the tubercular inflammation small, with no areas of coagulation necrosis or bronchiectasiæ, then the inflammatory products may be absorbed, the lung return nearly to its normal condition, and the patient recover" (Delafield).

Chronic Forms of Pulmonary Tuberculosis.—The disease may begin in various ways. Possibly without any impairment of the general health the first symptom noticed is the expectoration of blood. There are certainly patients who deny that any other change from normal has been noticed, and in whom nothing can subsequently be detected. They may, in fact, become perfectly healed. In these hæmoptœic cases we must realize that the tuberculosis preceded and was not the effect of the hemorrhage. On the other hand, the majority show a lowering of the general health. They feel languid, are easily tired, have no appetite, and have lost weight. Cough may have been noticed but is ascribed to other reasons, such as pharyngeal catarrh or the use of tobacco. Expectoration may be absent at first, but eventually a small amount of mucus is raised once or twice a day, and in it tubercle bacilli may usually be demonstrated and thus settle the diagnosis. Their absence, however, must not lull our suspicions. Some cases begin as an apparently simple pleurisy, with or generally without effusion, and, after an interval of good health following recovery, go on to a chronic progressive pulmonary tuberculosis. The general tendency of medical thought is toward believing that the great majority of pleurisies which have no definitely known cause are tuberculous in origin, but with a good chance for complete restoration to health. These patients should be well watched. Again, some cases furnish an attack, or several attacks, of laryngitis as the first evidence of tuberculosis, although the lung is nearly always the site of the original trouble if we could but detect it. In many young women the development of anæmia, and later of amenorrhœa, will cause them to seek medical advice, and then it will be discovered that tuberculosis is the primary cause of all the trouble. Digestive disorders, otherwise inexplicable, may, in some instances, be found to be due to pulmonary trouble. As a rule, most cases show an acceleration of the pulse and a slight rise of temperature in the afternoon or evening. In old people it is wise to remember that emphysema may serve to disguise the tuberculosis, and it is a safe rule to examine the sputa for tubercle bacilli as a routine measure, certainly in all who are losing flesh. The same may be said of those cases of influenza in which the respiratory symptoms persist. As the disease progresses the picture becomes easier to understand, but far more difficult to treat. The cough becomes more persistent, often paroxysmal, and at times accompanied by vomiting. The expectoration is more and more abundant and in it bacilli are more easily demonstrated. The amount may reach a half pint or more in twenty-four hours, in the advanced cases. The sputa are rarely offensive in odor when fresh, unless bronchiectasis or gangrene exists. Elastic fibres may be demonstrated. In the fibroid form of tuberculosis the bacilli are sometimes absent at intervals. Hemorrhages, so much dreaded by the patient, vary in extent from blood-streaked sputa to one or more pints. These may come on after exertion or when the patient is at rest. They occur in about half the cases. The origin of the blood is at the congested areas or from the branches of the pulmonary artery which undergo erosion. They would be more frequent were it not for the occlusion of these vessels by thrombosis. Small aneurismal dilatations of these arteries may also burst and cause bleeding. If the hemorrhage is followed by an increase in fever, it is generally due to a further invasion of the lung. Fever is regularly present; even in the almost latent form some rise at some time can be shown by the thermometer. In the fibroid form the temperature is often subnormal. The fever may be intermittent, remittent, or of the inverse type, *i.e.*, higher in the morning than in the evening. It is a very good index of the activity of the disease, although toward the end we fail to obtain any high readings of temperature; but the evident increasing exhaustion will serve to show that the fever's decrease is not due to improvement. The weakness of the patient regularly varies with the acuteness or the duration of the disease. In the sharp attacks the lesions may be indefinite, yet the patient is far sicker than in the chronic form, in which there are fairly well-marked signs. Of course the steady progress of the disease is accompanied by a commensurate asthenia, and eventually the patient becomes bedridden. Chilliness, more rarely a rigor, may be noticed as the fever rises daily.

Night-sweats are present in nearly all the advanced

cases and in some of the earlier ones. They occur with the fall of temperature, and by some are ascribed to the accumulation of CO_2 in the blood, from disturbance of respiration during sleep, and by some to the toxæmia. They occur generally in the early morning or near midnight. A good index of the activity of the disease is also to be found in the loss of weight. In the usual progressive case it is gradual but fairly constant, with perhaps intervals of quiescence, allowing it to become stationary or even at intervals to increase slightly. Some patients by careful feeding may be made to gain weight for a time, yet the disease appears to go on; while others who have become apparently cured, when they again become active workers, lose some of their accumulated fat, yet are none the worse. Digestive symptoms are prominent in many cases, anorexia and vomiting causing the patient to eat so little that semi-starvation ensues. A good digestion gives the patient a fighting chance and is a favorable element in prognosis. Dyspnœa on exertion is very common and in advanced cases always prominent. It is remarkable how little air hunger is present when the patient is at rest, even when the lesion is marked. The respiration rate is hurried, however, in proportion to the amount of lung involved, the extent of the anæmia, and the degree of asthenia. Fever also increases the rapidity of the breathing. The mental condition of the patient is often sanguine in the early part of the disease, although not always. The later hemorrhages, vomiting, sweats, and, in intelligent patients, the knowledge of the progress of the trouble, often lead to much lowness of spirits. Neuritis may be present. Sexual desire abates with the strength. Pleuritic pains and diarrhœa are common symptoms. The complications lend their added burden to a disease which alone is distressing enough.

Results of Physical Examinations.—This part can best be treated separately, but a knowledge of the pathological changes is absolutely necessary to interpret them properly. On inspection the chest may show the so-called paralytic form. The thorax looks flat, but if we measure it carefully we shall find it actually more rounded than normal, approaching the shape of children's chests and possibly being due to a lack of full adult development. The scapulæ are carried forward, a condition that is due largely to the rounded posterior portion which affords a poor resting-place for them. The chest index, according to Woods Hutchinson's measurements, is about 79.5, while in the normal adult chest it is 71. This index is found by dividing the antero-posterior diameter by the transverse. Above and below one or both clavicles we may find retraction and insufficient expansion. The whole of one-half of the chest may expand but little; especially is this marked in the fibroid forms. By studying Litten's diaphragm phenomenon we also obtain evidence of adherent pleuræ or a loss of elasticity in the lung. Owing to the fact that the heart is somewhat uncovered in disease of the left lung, we discover that the cardiac motions are transmitted to the chest over an abnormally large area. Often the heart is displaced markedly.

Palpation serves to substantiate the points shown by inspection. We should test the tactile fremitus, which is increased over areas of consolidation and over cavities, while diminished when the pleura is thickened to any extent.

In percussion we have a most valued test of the physical condition of the lungs. In those cases in which but a few miliary tubercles exist there is sufficient air in the lung to give good resonance, but sooner or later their increased number, the occurrence of partial or complete consolidation, and pleural thickening cause a distinct comparative dulness, generally recognizable at first in the clavicular and supraspinous regions. This may be best demonstrated by percussing from below upward and comparing the corresponding interspaces of the two sides. We must make due allowance for the physiological dulness found normally at the right apex, where also the tactile fremitus is more distinct and the breathing more broncho-vesicular. Cracked-pot and amphoric notes are generally indicative of cavities. There may be a change in pitch in the note obtained over a cavity when the patient alternately opens and shuts the mouth, and a similar difference may be noticed when the patient is percussed in the erect posture and when he is percussed while reclining. If much consolidation surrounds a small cavity the latter may easily escape detection. Emphysema also adds confusion.

Auscultation may be negative or may alone afford us a diagnosis. The early lesions generally show a slight diminution in the clearness of the vesicular inspiratory murmur at the apices. The expiration becomes more and more prolonged and of higher pitch. A localized cogwheel breathing may be present, but is not significant if no other signs appear. The breathing may simply be harsher than normal. As the consolidation advances, the bronchial quality in the voice and breathing becomes more and more manifest, yet rarely is it as distinct as in lobar pneumonia. Râles, chiefly subcrepitant, mucous, squeaking, and rubbing in character, are highly significant when confined to an apex. As softening begins the râles become moister, and when cavities are present, gurgling sounds and even metallic tinkle may be detected. The pleuritic adhesions, regularly present, give their appropriate signs. The heart sounds are often transmitted through consolidated areas with remarkable clearness. Cavernous breathing, with its hollow character and low-pitched expiration, shows the presence of an antrum, while whispered and spoken voice also indicate a reverberating cavity. Cardio-respiratory murmurs are often present, and can be distinguished by their being better heard at the end of inspiration, by the fact that a change in position often alters them or causes their disappearance, and by the fact that they are nearly always systolic. It must be remembered that, as a cavity fills with muco-pus and then empties itself, the signs will vary considerably, this very changeableness often affording us a clew to the condition present. We should not examine the apices only for signs of the disease, for in a small number of cases these signs may be best discerned at the base, at the apex of the lower lobe, in the upper axilla, or at that portion of the lung which is near the heart's apex. Radioscopy is helpful in determining the excursion of the diaphragm, the shadows of consolidation, and the light areas of excavation.

Diagnosis.—This is often rendered possible only by the detection of tubercle bacilli in the sputa. On the other hand, the bacilli may be absent, or we may be unable to obtain the sputa, and yet a true clinical diagnosis can be made. In doubtful cases the expectoration should be stained and examined; and if only negative results are obtained after several trials and yet tuberculosis is suspected, we should inject a guinea-pig with some of the sputum and watch for a following tuberculosis in this most susceptible animal. We should inquire for symptoms of tuberculosis in unexplained anæmias, in chronic dyspepsia, in persistent bronchitis, in atypical pneumonias, in pleurisies, and in emphysema where there is loss of weight. On the other hand, we should not allow the physical signs and general symptoms of malignant pulmonary growths, bronchiectasis, and gangrene to lead us astray.

The exact value of the tuberculin reaction is not settled, but it may at present be considered a valuable but possibly not harmless aid in diagnosis. As a means of securing a positive or a negative proof it is not above doubt. All cases with afternoon fever, emaciation, recurrent hoarseness, or apical physical signs, however slight, should be carefully watched. The administration of potassium iodide is recommended by some authors for the purpose of making râles more evident, while others claim that in some cases this procedure will cause an extension of the disease.

Treatment.—In this age it is the physician's duty to prevent as well as to cure, and in tuberculosis of the lungs we have warnings in the family history and healed lesions elsewhere which warrant our taking special precautions. Children who inherit a tendency to lung dis-

ease should not be nursed by a tuberculous mother, but should have a wet-nurse, thus avoiding the drain on the mother, the infection of the offspring, and the dangers of artificial feeding. Later, an out-of-door life in a pure, wholesome atmosphere should be ordered. The city is a poor place of residence for such cases, on account of dusty and infected air and the difficulty of tempting the child to indulge in out-of-door sports. Parks afford an approach to the desired purity of air; and where it is impossible to send children away, they should live in these open places as much as possible. Their studies should never be permitted to interfere with their physical development. Good, wholesome food, plenty of milk and cream, and cod-liver oil during the colder seasons, tend to increase their resisting power. They should have sunny, well-ventilated rooms, which should be kept fairly cool; and even in winter direct access of fresh air should always exist. Cool morning sponge baths with a brisk towelling tend to lessen the chance of catarrhal troubles and to harden the child. These general hygienic measures when begun at an early age are more easily continued, and, it is needless to add, they should be employed throughout life. When the general health of predisposed individuals becomes run down, we should order a rest and change of climate until they have fully recuperated. Especially is this true when the respiratory organs are damaged after influenza, measles, or pertussis. Apparently slight catarrhal conditions may either predispose to tuberculosis or be really such in a form too mild to recognize.

In acute and subacute pulmonary phthisis the patient should be kept in bed and every endeavor made to build up the strength by nutritious food. If possible, overfeeding should be employed. Milk and raw eggs at frequent intervals should be administered to the point of toleration. This cannot be insisted upon too much. Hæmoptyses are best treated by rest and opium. Fever is best controlled by a sponge bath in the late afternoon or evening. Antipyretics are generally best avoided. If the acute symptoms subside, creosote inhalations are to be employed; and, if the strength warrants the procedure, a dry inland climate must be sought. A few cases do well on ocean voyages if they can be well fed and have an airy cabin, and if at the same time they are good sailors. Arsenic, iron, and cod-liver oil may be used later. Codeine and heroin are useful when cough is exhausting.

All sputa from tuberculous members of a family should be destroyed, preferably by burning. The danger lies in the dried pulverized expectoration, which is then in a condition to be blown about, and not in that which is kept moist, as it is in the sputum cup. Carbolic-acid solutions (twenty per cent.) are a fair substitute for burning where the latter is not convenient. Handkerchiefs, napkins, bed clothes, and table utensils should be scalded and thoroughly cleaned, or, better, boiled in an alkaline solution before cleansing. In this way, with care, the danger of infection within the house is rendered less than that which exists in an ordinary life in the city. At Seton Hospital, during its eight years of occupation by consumptives, only one case, and that a doubtful one, has occurred among the physicians, nurses, or other occupants of the institution; and yet this hospital harbors from one hundred and fifty to two hundred consumptives most of the time. In the single case just referred to, there was a history of pneumonia which may have been tuberculous in character.

Of the curative measures diet, climate, out-of-door life, and rest are the essentials. The diet must necessarily be suited to the individual; generally, rather small, frequent meals serve our purpose best. In certain cases the three ordinary meals of the day should be taken, while milk and raw eggs should be administered between times and on retiring. A limited overfeeding can thus be taught to some who are by habit light eaters. The point to be gained is to have the patient take as much wholesome, nutritious food as his digestive organs can assimilate. Perhaps a little wine or beer might be taken by these patients when they serve as appetizers, but great care should be observed that we do not irritate that most important organ of the consumptive, the stomach. If any course of treatment upsets the digestion it is a safe rule to discontinue it, for by no method can we obtain strength for the patient unless feeding is possible; and in consumptives we have to feed our patient, and also to make up for the constant drain caused by the disease. A carefully selected dietary, varied, digestible, and appetizing, will often coax the patient to eat quite heartily. Much skill in serving dishes—by making them attractive, by not overloading the plates, and by division into dainty courses—can be shown, and this well repays the trouble. Milk and raw eggs can often be given in large amounts when solid food is rejected. I have known some patients who could retain raw eggs, taken whole, like a soft capsule, and flavored with a little sherry, when milk and broths were promptly vomited by them. Cod-liver oil in not too large doses is of help if it does not impair appetite. Cream and ice-cream also are palatable forms of fatty food, which is of course particularly indicated in consumption. Butter spread on very thin slices of bread is well taken at times. Rest is also important, due regard being paid to individual peculiarities. If fever is present, the rule is to keep the patient at rest. If the afternoon fever does not exceed 100° F., exercise may be permitted, but should be carefully watched. Exhaustion and lack of appetite after a walk mean that harm is being done; and the temperature, if taken immediately after exertion, should not exceed 101° F. Of the different forms of exercise, walking, bicycling, and horseback are perhaps the best, and should be leisurely but steady in character. The general opinion among those specially dealing with tuberculosis is rapidly forming in favor of a rest-cure in cases which are at all active. Under this régime the appetite, instead of suffering, improves, the fever and emaciation become less marked, and often flesh is quite actively gained. A steamer chair or couch should be placed on the porch in a place which is shielded from wind and rain, and should be occupied for at least eight hours daily. Coldness of the weather should be disregarded, but ample covering of body and limbs should serve to keep the patient comfortable. At first these measures are not kindly accepted by the patient, to whom cold is often disagreeable, but a tolerance is soon established, and he soon learns to love the method and ceases to criticise. In a few cases moderate exercise agrees somewhat better, but these are exceptions.

The well-known beneficial effect of change of climate compels us to select a locality which will suit the individual case. If, after a trial of two or three months, the results are not satisfactory, we should seek another region, with the hope that it may prove more favorable. Simply a change at fair intervals acts beneficially in the case of those of a restless temperament; but if we are satisfied that all is going well, we should be slow to allow a departure from a region which is accomplishing our purposes. We can judge of the effects as being beneficial when the patient begins to feel stronger, improves in appetite, sleeps well, and gains in weight, while cough and expectoration lessen. The essential requirements of any region should be plentiful sunshine, purity of atmosphere, and an equable temperature. A climate in which the individual may be out of doors most of the time, which is dry and of fair altitude, should be selected if possible. All these requirements cannot be supplied by a single locality, but we should select one which answers as nearly as possible to the desired standard. The Adirondacks, Sullivan County in New York, Görbersdorf in Silesia, and Falkenstein in Southwest Germany, together with those vast areas in the southwestern portion of the United States, such as portions of Arizona, New Mexico, and Texas, are deservedly popular. Southern California has given good results and is a delightful, sunny region. The higher altitudes, such as the Colorado resorts (5,000–6,000 feet), Davos (5,000 feet) and St. Moritz (6,000 feet), are preferred by some, but they have the disadvantage of making the cured cases so dependent upon this bracing atmosphere that a

return to the seaboard is often impossible. The emphysema which follows residence in these high places may account for this peculiarity. Cases with weak hearts, marked emphysema, arteriosclerosis, diabetes, and active or advanced lesions, should not be sent to great altitudes. Patients who have occasional hæmoptyses may be allowed to go to the mountainous regions, but they should make the ascent gradually, resting for several days at intermediate levels. In the case of those who are in the advanced stages of the disease, the question of a congenial home life must be weighed against the beneficial effects of climate. We must bear in mind that many apparently hopeless cases are enabled to live an active life in a suitable region, and we must not lightly allow sentimental reasons to overthrow our judgment. Although benefit is improbable it is not impossible.

The use of tuberculin as a curative measure is still in the experimental stage, but there is some evidence that it has beneficial results, both as a healing agent and as a preventive of relapses. It should be given cautiously, in doses of from 0.2 to 0.5 mgm., to be gradually increased; but care must be taken not to increase the dose to the point at which it produces any marked constitutional symptoms. It should be employed only in the incipient cases, which of course are those which give the best results under all methods of treatment.

Creosote still holds its place as the main drug in treatment. It seems to benefit the cough, to lessen the expectoration, and to improve digestion. The enormous doses often prescribed are not to be recommended; five or six drops well diluted and given after meals, should suffice. Creosote can also be given by inhalation, a few drops of a solution of equal parts of creosote, alcohol, and chloroform being placed daily on the sponge of a perforated zinc inhaler. Carbonate of guaiacol, creosote carbonate, and palmiacol have the advantage of not being so irritating to the stomach, and should be used when the crude drug disagrees. Ichthyol, arsenic, and strychnine are employed with varying success by some clinicians.

The symptomatic treatment is of importance, and is sure to tax the resources of the physician. Cough is necessary, and is sometimes best left untreated; but, again, if it is unnecessarily harassing, it may cause lack of rest and even vomiting, and drugs then are useful. The morning cough has the purpose of ridding the lungs of the accumulated secretions of the night. A hot alkaline drink here serves our purpose best, for we wish to promote and not to check it. A mixture made by adding bicarbonate of soda and a little glycerin to a couple of ounces of hot water, will be found to answer well the desired purpose. The severe coughs with but little expectoration can often be benefited by treating the pharynx and larynx locally. Ipecac, ammonia, steam inhalations, heroin, codeine, and morphine also render effective aid at times. The use of morphine is absolutely necessary in advanced cases, but we should wait as long as possible before employing it, as it upsets digestion only too often. If the cough is pleuritic in origin, adhesive straps and counter-irritation may prove useful.

Anorexia is difficult to combat and is frequently present. A simple alkaline bitter, such as bicarbonate of soda with nux vomica and compound tincture of cardamom, taken before meals, is often most successful. Acids with nux vomica after meals suit some cases better. Vomiting may be relieved by oxalate of cerium, bismuth, and pepsin, by lavage, and by dietetics. Some light wine with meals may serve to start digestion, while often simply looking after the cough will stop the vomiting and remove the dread of eating from the patient. Diarrhœa may be avoided or stopped by dieting and by the use of opium, tannic acid and derivatives, by rest, and by the application of warmth over the abdomen. If it is of ulcerative origin we have a most intractable condition, but it should be checked as much as possible, in order to prevent the terrific drain on the patient's strength. The measures enumerated above may be supplemented by starch and laudanum enemata and by astringent acid draughts.

Dyspnœa, which occurs in attacks, is best managed by rest, alcohol, heart stimulants, and oxygen. If the cause be a pleural effusion, aspiration should of course be employed; if pneumothorax, adhesive straps should be applied to the side at fault, and morphine, as well as cardiac stimulants, should be administered cautiously. Finally, if there be much intrapleural pressure, the air should be withdrawn under aseptic precautions.

Hæmoptyses are best managed by prescribing absolute rest in a half reclining position. The patient should be thoroughly reassured, and all interruptions to quiet reduced to a minimum. Only the attendants should enter the room, which should be located in a quiet part of the house. The bowels should be emptied thoroughly with a saline purge in order to divert as much blood as possible to the intestines. Cold may be applied to the affected side. In extreme cases ligation of the limbs may be indicated, the blood being allowed to return at intervals from each limb in turn. This method keeps the blood stored up in the veins and lessens its loss. The diet should be served cold, and must not be stimulating unless urgently needed. A poor circulation is rather beneficial under those circumstances and should be favored. As regards the use of drugs the writer prefers morphine, about one-fourth of a grain to be administered hypodermatically. The disadvantage of pushing this narcotic lies in the fact that the benumbing of the reflexes which it produces, may cause the blood to be too readily retained in the lungs and so drown the patient. The danger, therefore, lies in asphyxiation rather than in the direct loss of blood. Consequently, our aim should be merely to lessen cough, restlessness, and anxiety, but not to make the patient semicomatose. Atropine, ergot, gallic acid, hydrastis, and ipecac are recommended, but probably do no good. Ergot contracts the arteries, but it does not follow logically that it contracts the rupture in a vessel; in fact, quite the contrary may be true. The rise in arterial tension, which this drug causes, is also a distinct disadvantage.

Chills are best treated by warmth, rest, and alcohol.

Night sweats can often be checked by a hot bath taken just before retiring, and limited to five minutes' duration. A good remedy for the relief of this symptom is a pill which may be made of zinc oxide (gr. iij.), extract hyoscyamus (gr. ss.–i.), and strychnine (gr. $\frac{1}{40}$–gr. $\frac{1}{20}$). Camphoric acid (gr. xx.) is often very useful. Agaricin in large doses works well in some cases. A light midnight meal and sponging with dilute acid washes are measures which should also be tried. Atropine sulphate is the most reliable drug, given hypodermatically in gr. $\frac{1}{100}$ doses, but it has a disagreeable effect on many.

Pyrexia is best treated by rest and cold sponging; rarely should we employ the coal-tar derivatives. If the stomach is not irritable, quinine in large doses may control the fever to some extent. Pleuritic pains are most effectively relieved by a tight strap of adhesive zinc oxide plaster, applied to the affected side in such a manner as to lessen its mobility. Counter-irritation by blisters, iodine, or cupping, is helpful.

In conclusion, we may add that the general weakness is best combated by good feeding, rest, alcohol, and such means as promote the patient's comfort. Morphine is necessary in many cases, and when the patient's condition is hopeless we are justified in giving large doses as tolerance becomes established. The treatment of the many complications is considered elsewhere.

Arthur Melville Shrady.

LUNGS, DISEASES OF: TUMORS.—Benign neoplasms in the lungs, whether arising in the bronchi or in the alveoli, are apparently of very rare occurrence, although, as they cause very slight disturbance during life, they may often have been overlooked. The few cases reported seem to have been discovered accidentally at autopsy; only one, that of Mackenzie, having been discovered during life. The list of benign growths which have been found in the lungs and bronchi—exclusive of the trachea—includes lipoma, lipomyoma, papilloma,

myxoma, osteoma, enchondroma, chondro-angioma, lipochondro-angioma, mucous adenoma, and colloid adenoma, most of them being represented by only one, or, at the most, two cases. Rokitansky reported a submucous lipoma growing in the wall of a bronchus, and in another case a colloid adenoma, apparently originating in a misplaced portion of thyroid tissue within the wall of the right bronchus. Chiari found a mucous adenoma in the wall of a bronchiectatic cavity, and a lipochondro-adenoma in the wall of a second similar cavity. He quotes Laboulbène as having examined a lipoma with areas of spindle cells—perhaps smooth muscle fibres—from the bronchial submucosa. Papillomata were described by Williams in non-carcinomatous bronchi in a patient dying of mediastinal carcinoma. The case reported by Mackenzie leaves some doubt as to the exact situation of the papilloma. A polypus had been removed from the larynx of the patient, but the attacks of dyspnœa still recurred, and finally, after severe coughing, a small mucous polypus was expectorated. The greater frequency of tracheal polypi as compared with bronchial makes it probable that this growth also was in the trachea.

The statement is usually made in the text-books that enchondroma is a comparatively common tumor of the lung, and that it arises from the cartilage of the bronchi. A careful examination of the literature, however, shows that very few cases of enchondroma have been reported, and that of those few, not nearly all can be traced to the pre-existing bronchial cartilage. It is even denied by Cornil and Ranvier that such growths ever occur in the lung, but we have the testimony of no less an authority than Virchow to their occasional occurrence at the root of the lung, and even, rarely, in the parenchyma near the surface, arising from the connective tissue. Siegert's case is one of the few instances of an enchondroma which could be directly traced to the bronchial cartilage, growing within the wall of the bronchus and covered with ciliated epithelium. Hyaline cartilage is the form usually found, although sometimes the elastic variety is observed; the cells may be typical or larger than usual, arranged in islands surrounded by an elastic or a hyaline matrix. Usually the growth is surrounded by a vascular capsule which passes in and divides it into lobules. Ossification of the stroma and calcification and mucous degeneration with cyst-formations have been found. Virchow has described an enchondroma with a very vascular stroma under the name of enchondroma telangiectoides; Siegert, a similar growth under the name of chondro-angioma. Virchow has also described a pure myxoma of the lung, and Rindfleisch a case of multiple osteomata.

It has for a long time been supposed that primary malignant tumors of the lung were among the rarities of pathology, but a careful collection of statistics shows that they are not so uncommon, and that they make up an appreciable percentage of all malignant neoplasms. Of the different varieties, carcinoma, sarcoma, and endothelioma, the first is by far the most important numerically, although it is not always possible to be sure that endotheliomata have not been included in the list. The later statistics of malignant tumors of the lung show an increase over the earlier. Thus Reinhard, of the Dresden City Hospital, found in 545 carcinomata only 5 primary in the lung, or 0.9 per cent., while Wolf, thirty years later, found a steady increase since Reinhard's time. There were 31 cases of primary lung carcinoma in 7,228 autopsies, or .428 per cent. of all cases. Pässler's figures from Breslau are: 16 primary carcinomata of the lung in 870 carcinomata, 4 primary sarcomata of the lung in 130 sarcomata, making lung carcinoma 1.3 per cent. of all primary carcinomata. Men are far more frequently affected than women, the proportion being about 76 to 24, although Wolf finds the excess of men over women even greater than this. As to the most susceptible period of life, there are different opinions; Reinhard, Pässler, and Wolf place it between the ages of forty and sixty years; Osler and Hassa, on the contrary, find it most common between the twentieth and fortieth years, and Fuchs found that the sixty cases analyzed by him were distributed about evenly between the twentieth and fiftieth years.

The exact origin of malignant epithelial tumors of the lung is a disputed point among pathologists. On the one hand, we have the epithelial cells of the bronchi, both the lining cells * and the cells † of the mucous glands; on the other, the squamous cells of the alveoli. ‡ It is this last which has aroused the liveliest controversy, and which is still a disputed point.

Primary carcinoma in the lung may appear as multiple nodular growths along the wall of one of the larger bronchi, spreading through the lymph spaces of the peribronchial connective tissue in the form of a chain of beads. In this variety the relation between the bronchial branches and the neoplasm is easily demonstrable. A second form is the large, soft, isolated node or nodes, which although often near a bronchus, small or large, and including it in the growth, yet spreads not by invading the peribronchial lymph spaces, but by filling the alveoli. There is finally a third form which lies between these two, and which, although it apparently has its origin in the epithelium of the bronchial mucous glands or in the cylindrical cells of the mucosa, does not remain confined to the peribronchial connective tissue, but spreads out into the parenchyma, filling the alveoli. In both of these last two forms it is difficult to determine the exact origin of the growth, and it is here that the controversy arises as to the part played by the alveolar epithelium. The well-known tendency of proliferating epithelium to undergo metaplasia is well shown in these carcinomata, in which all varieties of epithelial cells may be found side by side. Pure cylindrical-celled carcinoma is not common, and even those growths which can be proved to have originated in the cylindrical epithelium of the bronchial mucosa often show transitional, polymorphous, and squamous cells; as in a case described by Siegert in which the original cylindrial cells of the bronchial epithelium gave rise to a squamous-celled carcinoma. On the other hand, tumors in which connection with the alveolar epithelium seemed to be established beyond a doubt, have shown a metaplasia from squamous cells to cylindrical cells.

The character of the cells cannot, therefore, be depended upon as an exact index to their origin, yet it is probably not merely a coincidence that the largest number of carcinomata in the lung contain cylindrical cells and that the largest number are situated in the bronchial walls. The disappearance of the mucous glands or the filling of the bronchi by the proliferated epithelium, can frequently be proven. In the case of carcinomata of parenchymal origin the point is harder to prove, as in such cases smaller bronchi are always included in the mass and might be regarded as the starting-point. There seems, however, no *a priori* objection to the development of a carcinoma from the alveolar epithelium; rather the contrary. Atypical proliferation of these same cells, leading to the formation of papillary outgrowths into the alveoli or of masses of large non-pigmented cells which lie free within the alveoli, may be observed in several chronic pathological processes in the lung: in chronic passive congestion, in syphilis of the lung (Ziemssen), in chronic productive inflammation following incomplete resolution after pneumonia (Siegert, Perls, Ribbert), and in the epithelium of alveoli which are in the neighborhood of, but not yet invaded by, a carcinomatous or sarcomatous growth (Friedländer, Wagner, Schulz). Metaplasia of the cells is often seen in these cases, the squamous cells giving place to tall cylindrical ones, and there is every reason to believe that these elements, which have taken on an embryonal character, might be the starting-place for a malignant growth. In Friedländer's case the carcinoma arose from squamous cells covering a tuberculous scar in the bronchial wall.

It can readily be seen from the above that the structure

* Chiari, Strümpell, Siegert, Ebstein, Schwenninger, Ziegler.
† Langhans, Pässler, Birch-Hirschfeld, Schafer.
‡ Perls, Lataste-Malassez, Grünwald, Friedländer, Wolf, Boix, Fuchs.

of carcinoma of the lung is subject to wide variations. The most common form is that which arises in the bronchial wall and consists of anastomosing cords of cylindrical and cubical cells, with a stroma formed from the peribronchial connective tissue, the growth extending along the lymph spaces. Less common are the polymorphous-celled form and the squamous-celled form with typical pearls and hornification.

The stroma of carcinoma of the lung is usually scanty, formed by the peribronchial connective tissue and the alveolar walls. Cornil and Ranvier deny that any new stroma is ever formed, and this is probably true in the earlier stages of the growth; but in older growths the centre may contain a very dense stroma with corresponding decrease of cells (Boix).

Mucous degeneration of the cells is quite common, especially in the peribronchial carcinomata; necrosis, fatty degeneration, and hornification have been found. In the case of tumors which communicate directly with a bronchus or a bronchiectatic cavity suppuration and gangrene may supervene. Carcinoma is probably the underlying cause of many of the cases of so-called spontaneous gangrene of the lung. Concretions corresponding to the corpora amylacea and corpora flava of Siegert, as well as calcareous concretions, have been described. Siegert found partial ossification of the stroma in a squamous-celled carcinoma.

The differentiation between carcinoma of the lung and endothelioma is extremely difficult. Pässler, after a careful review of the one hundred and thirty-two cases of so-called primary carcinoma of the lung, reported in the literature up to 1896, rejects no less than sixty cases, on the ground that the tumors described belonged to the endotheliomata, not to the carcinomata. The point is one which often cannot be decided with absolute certainty. In both we find large nests of epithelial cells filling the lymph spaces, and the crucial point, whether or not the endothelium of these lymph spaces participates in the growth, can hardly ever be determined positively. Malassez, Stilling, Siegert, and Schulz succeeded in demonstrating the unaltered endothelium surrounding the nests of carcinoma cells; while Rokitansky, Schulz, Schottelius, Neelsen, Schwenninger, and Wagner proved the endothelial origin of the growth in their cases. Usually a tumor composed of nests of large cells is pronounced a carcinoma without question; and Klebs is of opinion that in all cases in which the lymph spaces are invaded the endothelial cells participate in the growth. Practically it is very difficult to determine whether the endothelium merely surrounds the cell nests or blends with them, and the difficulty is still greater in those cases in which the atypical proliferation of alveolar epithelium, already described, occurs, and gives the appearance of an early stage of alveolar invasion.

Primary endothelioma may arise from either of the two systems of lymphatics, the superficial or subpleural, in which case the pleura is invariably involved, and the deep or pulmonal, in which case the tumor is apt to form near the root of the lung. It spreads along the interlobular lymphatics, forming chains of nodules.

The coincidence of tuberculosis and carcinoma in the same organ has roused much interest of late, and several cases have been reported of these two processes in the lung. Friedländer and Hildebrand both found squamous-celled carcinoma developing in the epithelium lining a tuberculous cavity. Schwalbe reported three cases of carcinoma and tuberculosis in the same lung and Wolf thirteen. Wolf's statement is somewhat startling; out of thirty-one cases of primary carcinoma of the lung he found thirteen complicated with tuberculosis, a number far exceeding all of those reported in the literature up to that time. Wolf's descriptions, however, leave nothing to be desired. Typical tuberculous nodules, caseation, giant cells, bacilli, in one case general miliary tuberculosis, seem to prove his assertion beyond a doubt.

Metastases from carcinoma of the lung are most common in the regional lymphatic glands, in the other lung, and in the liver, but may be found in any organ or tissue of the body. Pleura, pericardium, and bone come next to the above-named in order of frequency; less common are metastases in the heart muscle, diaphragm, kidney, adrenals, brain, and spleen; still less common are those in the peritoneum, thyroid gland, pancreas, and gall bladder. A singular situation for a metastatic growth was the centre of a myoma of the uterus. The wall of the œsophagus was invaded in one case, the venæ pulmonales in four, the arteria pulmonalis in four, and the venæ cavæ in five. There is no record of extension to the aorta.

Primary sarcoma of the lung is much less common than carcinoma. Pässler finds four of the former to sixteen of the latter. Sarcoma arises in the peribronchial or interlobular connective tissue. All varieties have been described—round-celled, spindle-celled, giant-celled, mixed-celled.

Secondary carcinoma and secondary sarcoma of the lung are of comparatively frequent occurrence. According to Reinhard the proportion of secondary malignant growths to primary is seventy-four of the former to five of the latter. In the case of secondary carcinoma the original tumor is apt to be situated in the mammary gland, pleura, liver, or stomach; in the case of secondary sarcoma the primary tumor is usually in bone. Secondary growths are apt to be multiple and to involve both lungs. Osler reports a secondary colloid carcinoma which filled both lungs, the primary growth being in the pancreas. In rare instances a single metastasis is found; as in another case of Osler's, a solitary tumor in the pleura, secondary to a myeloid sarcoma of the wrist. The mode of extension of secondary growths is almost always along the lymphatics; very rarely is there an infiltration of the parenchyma. They arise either by extension from neighboring tissues, as the œsophagus, bronchi, mediastinal glands, etc.; or from the pleura along the subpleural lymphatics, or from a distance along the pulmonal lymphatics; or, finally, by an embolus in the pulmonary artery. Aufrecht reports an interesting case of embolism, in a branch of the pulmonary artery, from a carcinoma in the gall bladder; the growth of the embolic carcinoma had not yet penetrated the adventitia of the vessel in which it had lodged.

The etiology of primary malignant tumors of the lung can be only a matter of conjecture in the great majority of cases. Trauma is undoubtedly an important factor; the great preponderance of male over female patients is enough to show that. Osler remarks on the frequency of primary lung carcinoma among the workers of the cobalt mines of Schneeberg. Two of the four cases reported by Aufrecht had a history of severe injury to the affected side of the chest, and Georgi and Löwenthal also could trace their cases to trauma.

In the diagnosis of primary malignant tumors of the lung a distinction between carcinoma, sarcoma, and endothelioma can be made only in those rare instances in which a portion of the tumor is coughed up with the sputum. The greater frequency of carcinoma makes that the most probable diagnosis. Clinically, the distinction is made not between malignant growths of different character, but between the deep-seated ones which arise at the root of the lung and the more superficial or subpleural ones. Roughly speaking, the former simulate mediastinal disease, the latter pleurisy.

Certain general symptoms are common to both the deep and the superficial growths, the most important of which is cachexia, in several instances the only symptom which pointed to a malignant tumor. Pain is a very variable symptom, probably depending largely on the extent to which the pleura is involved. It is sometimes entirely absent, sometimes very severe, like intercostal neuralgia, and it may run down the arm as well as the chest. A feeling of tension without definite pain is sometimes felt. Fever is not common, and when present should be regarded as a complication rather than as an inherent part of the disease, being due not to the tumor but to a pneumonic process, or to putrid infection of a bronchiectatic cavity, or to suppuration or gangrene of the affected part of the lung. Many clinicians lay stress upon the

enlargement of the supra- and infraclavicular lymph glands, but a careful review of the reported cases shows this to be a rare occurrence; nor could it, if present, be regarded as particularly significant, as such an enlargement might be caused by tuberculosis. Osler speaks of swelling of the axillary and even of the inguinal glands, but those cases are very exceptional.

Cough is often absent; when present it may be slight, with little sputum, or severe and persistent, with abundant sputum. A decided difference of opinion exists among the authorities on the subject of the sputum of malignant tumor of the lung. The majority of text-books on medicine lay great stress on this point and consider the characteristic sputum to be the most valuable of all aids to the diagnosis of this obscure affection. As to the kind of sputum, however, which is to be considered characteristic, the opinions differ widely. Some describe it as thin, mucoid, of purplish-brown color, the "prune-juice" sputum. Stokes found this present in ten out of eighteen cases, and thinks it of great diagnostic value. Others describe a reddish, jelly-like substance, sometimes likened to raspberry jelly, sometimes to currant jelly; still others describe it as bright green in color, with large green balls of muco-pus. It may be scanty and non-odorous or abundant and fetid. Blood is often found; Boyd found it in the sputum of more than half of his forty-nine cases. The truth is, that the sputum in malignant tumors of the lung depends not on the primary disease so much as on the extent and character of the bronchial inflammation, the amount of hemorrhage, and the formation of bronchiectatic cavities, etc. The color of the sputum, the presence or absence of blood, the consistence, odor, etc., cannot be regarded as diagnostic, for tuberculosis, bronchiectasis, pneumonia with slow resolution, lung abscess, may cause any of the different kinds of sputum which have been described as characteristic of lung tumor. The only kind of sputum which is absolutely pathognomonic is that which contains portions of the tumor. The references to these in the current text-books would lead one to infer that such sputum is not unusual; but a study of the literature reveals the fact that only five cases have been reported in which portions of the tumor were found in the sputum, three of these five being primary carcinoma, two secondary sarcoma. In the case described by Haempeler, of secondary sarcoma of the lung following a primary bone sarcoma, fragments of tissue were found in the sputum, and these proved to be round-celled sarcoma. Eichhorst's case of secondary sarcoma was similar to this. The three cases of carcinoma were not quite so clear, for the sputum did not contain shreds of tissue but only single cells, resembling alveolar epithelium but much larger, multinucleated, and non-pigmented. The case of Krönig is interesting in this connection. He made an exploratory puncture to ascertain whether the dulness present was caused by a collection of fluid; and, failing to obtain any fluid, he made a second attempt with a larger needle and succeeded in removing bits of tissue composed of round cells. The growth proved to be a sarcoma.

The involvement of the pleura often gives rise to the most prominent symptoms, masking the underlying disease. By many authors the hemorrhagic character of the effusion is emphasized; but Moutard-Martin found hemorrhagic pleurisy in only twelve per cent. of the two hundred cases analyzed by him, and Aufrecht goes so far as to say that this form of pleurisy is more common in non-carcinomatous than in carcinomatous cases. The effusion may be abundant, sero-fibrinous, or purulent. The attempt to find cancer cells in the exudate has never succeeded.

So far, the symptoms have been the same for both the deep and the superficial tumors, but in considering the physical signs the two forms must be dealt with separately. Generally speaking, the subjective symptoms are more pronounced in the deep tumors, the physical signs in the superficial. In the deep tumors we have chiefly the disturbances due to pressure upon the nerves, vessels, bronchi, and œsophagus, while the physical signs of a new growth may be entirely absent. Inspection sometimes reveals a fulness of the affected side with obliteration of the intercostal spaces, but this is more common in the superficial tumors. Later on, contraction of the connective tissue and collapse of atelectatic lung tissue may cause a narrowing of the chest wall. There may be diminished expansion of the affected side. Lividity of the chest on that side and of the corresponding arm has been observed, but usually only late in the course of the disease. Gradually increasing dyspnœa is greater in this form than in the superficial, and is both inspiratory and expiratory; sometimes more extreme than is the case in tuberculosis.

Percussion reveals no abnormality in the early stages, but often there is a sudden development of dulness with loss of respiratory sounds, more absolute and more rapid than is usually the case in tuberculosis. Woillez speaks of a tympanitic note on percussion during the earlier stages due to loss of elasticity of the lung tissue, this note then changing suddenly to complete dulness.

The signs on auscultation are those produced by pressure on the bronchi—stridor or weakness or complete absence of the respiratory sounds. The normal tracheal breathing is also apt to be weakened. Curschmann has pointed out the fact that in tumor of the left lung the heart sounds are better conducted through the solid mass than they would be through a pleuritic effusion.

Pressure on the neighboring structures is responsible for the most prominent physical signs and symptoms in the deeply seated tumors. The heart may be displaced; the veins may be compressed and lividity with œdema of the upper, less often of the lower extremity, may result from this narrowing; pressure on the recurrent laryngeal nerve may cause changes in the voice; pressure on the œsophagus may cause difficulty in swallowing. As to this last, a slight compression is not unusual; an extensive compression, however, is very rare. Pressure on nerves other than the recurrent laryngeal almost never occurs. The growth may not only compress the vessels but may involve their walls and lead to rupture with fatal hemorrhage. Such extension has been observed in the case of the venæ cavæ, the venæ pulmonales, and the arteria pulmonalis; never in that of the aorta.

As to the diagnosis between carcinoma at the root of the lung and mediastinal tumor, the chief points are: that the mediastinal growth is apt to attain greater dimensions than the lung tumor, so that a large area of dulness under the sternum would more probably mean the former; that dyspnœa develops earlier in lung tumor than in mediastinal tumor; and that compression of the vessels with lividity develops earlier in the mediastinal. Signs of compression of the vena cava superior coming on early and followed by dyspnœa would, therefore, speak for a mediastinal growth; the reverse order is the rule in lung tumors. On the other hand, involvement of both recurrent laryngeal nerves, without signs of aortic aneurism and without compression of the vena cava superior, would speak for the lung tumor.

The second class of tumors, those which arise in the smaller bronchi or in the parenchyma and are more superficially situated, give often the clinical picture of pleuritis alone, especially when confined to the lower lobes. The line of dulness, which does not change with change of position, is a valuable diagnostic point. Dulness and loss of respiratory sounds are easier to demonstrate in these tumors than in the deeper ones; pain is more severe; but dyspnœa and symptoms due to pressure on vessels and nerves are often entirely absent. The diagnosis between these more superficial tumors and tuberculosis is extremely difficult. The absence of tubercle bacilli in the sputum, the late involvement or non-involvement of the apex, the fact that dulness is apt to be greater in front than behind, and to be absolute with complete disappearance of respiratory sounds, these are the chief aids to differentiation between the two processes.

The diagnosis of secondary growths is necessarily simpler. Symptoms referable to the lungs arising in a patient with a previous history of carcinoma or sarcoma

would at once arouse suspicion and lead to a diagnosis which might not have been possible in the absence of a primary growth. However, in both primary and secondary growths inflammatory processes in lung and pleura may completely mask the true nature of the disease, and consequently it is not strange that many cases are reported in which the diagnosis of pleurisy with effusion was made; while there are others which were diagnosed as lung syphilis, lung abscess, gangrene, chronic pneumonia, tuberculosis, etc. Pässler records a case of fatal hemorrhage from the right branch of the pulmonary artery which had become invaded by a lung carcinoma, although there had been, up to the end, no symptoms that could be referred to the lung.

The duration of the disease is said to be from six to eight months, but Ziemssen reports a case which extended over several years, and which, strangely enough, improved temporarily on antisyphilitic treatment. On the other hand, Jaccoud reports one which was fatal within a week after the first appearance of symptoms.

Treatment of the disease is necessarily palliative only and must be directed to controlling complications and relieving pain. No possible therapeutics for malignant growths in the lung can be formulated.

Alice Hamilton.

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LUNGS, DISEASES OF: WOUNDS. See *Thorax, Surgery of the.*

LUNGS, PHYSIOLOGY OF. See *Respiration.*

LUNGS, SURGERY OF. See *Thorax, Surgery of the.*

LUPETAZINE—dimethyl piperazine, dipropylene diamine, $[HN.(CH_2.CH.CH_3)_2.NH]$—is a white crystalline powder of the same dosage and therapeutic uses as piperazine. *W. A. Bastedo.*

LUPULIN.—Lupulinum.—"The glandular powder separated from the strobiles of" hops, U. S. P. The origin of this substance has been fully described under *Hops.* It is thus described in the Pharmacopœia:

"Bright brownish-yellow, becoming yellowish-brown, resinous, consisting of minute granules which, as seen under the microscope, are subglobular, or rather hood-shaped, and reticulate; aromatic and bitter.

"When lupulin is agitated with water and the mixture allowed to stand, no considerable sediment (sand, etc.) should be deposited. When ignited, lupulin should not leave more than ten per cent. of ash."

It is obtained from the hops by abrasion, and should then be stirred upon the surface of water to remove heavy impurities, with which it is often greatly adulterated. Such adulteration is readily detected by estimating the percentage of ash, for which the above-named ten per cent. is too liberal an allowance.

The differences in composition and action between hops and lupulin are chiefly those of degree. It yields about three per cent. of volatile oil and a proportionately greater amount of the bitter principle, but lacks the tannin. It is given in doses of from five to thirty grains. The Pharmacopœia provides a fluid extract and an oleoresin, the dose of the latter being from one to five grains.

Henry H. Rusby.

LUPUS ERYTHEMATOSUS.—A disease of the skin which has some of the clinical features of lupus vulgaris, but from which it is absolutely distinct in that the tubercle bacillus of Koch is now known to be absent from its lesions. The name was first used by Cazenave in 1850, and is to-day the recognized name for the disease throughout the world. Unfortunately, the nature of the process is obscure, there being nothing in the histological appearance of the lesions which can be said to be distinctive of lupus erythematosus. The process commences in the upper corium and consists of an exudation of round cells. This has caused some investigators to regard the nature of the process as inflammatory, and they have acccordingly assigned the disease a place in that group. Although this is a decided advance from the position of the earlier dermatologists who placed the disease among the cellular neoplasms, the truth is that even to-day one can find very little in the enormous mass of literature on lupus erythematosus that is available as a basis for a comprehensive definition of the disease.

In sharp contrast with the vagueness of its etiology, the clinical position, in dermatology, of lupus erythematosus is clearly defined. Typical examples of the disease are easy of recognition, for they all have certain marked characteristics. The lesion consists of areas of persistent erythema extending at the margin at a slow rate, and showing a marked tendency to sink in at the oldest portion, a phenomenon to which the name of central atrophy has been given.

Symptomatology.—Lupus erythematosus, as it first appears, consists in the formation of one or several slightly raised areas of a bright red color, from the size of a pinhead to that of a bean. These areas do not entirely disappear on pressure, and their color is apt to vary a good deal from day to day, sometimes nearly fading out and at other times being intensely red. After the disease has remained in this state for an uncertain period peripheral extension occurs; that is, the sharply defined patch of erythema gradually increases in area through the involvement of the adjacent skin. At the same time the central area is seen to be covered with scales. These scales are usually small and very adherent. On attempting to remove them, one sees that they are attached to the sides of the mouths of the sebaceous follicles, which seem to be early affected in the disease by an abnormal hyperkeratosis that extends deeply into the glands. The rate of extension varies greatly, but the process has always a chronic course. Sometimes there is extension at one part of the border without any change at the remainder, and often the entire patch may remain for months without appreciable enlargement. The changes in the central area of the patches are equally uncertain, but usually the atrophic tendency can be recognized in most cases. This consists in a sinking-in of the patch in this region with a decided lessening of the color. When the lesion is fully developed, the atrophic skin is white and glistening, somewhat resembling a cicatrix, from which it differs microscopically and clinically by the absence of true scar tissue. Furthermore, it does not contract and displace the adjacent parts. In favorable cases the erythematous border may entirely disappear, leaving only the atrophic centre which is absolutely permanent. This termination is rare, however, most cases showing activity in some part of the integument for years. Sometimes the lesions are the site of other processes, among which true lupus and epithelioma are the most important.

The commonest seat of lupus erythematosus is upon the face. Here the disease often shows itself with absolute bilateral symmetry. The "butterfly lesion" of Hebra is classical and is formed by the involvement of the cheeks and the dorsum of the nose, the areas on the cheeks representing the two outstretched wings of the butterfly and that on the nose its body. At times in connection with this lesion, and at other times existing alone, lesions of the ears, scalp, eyebrows, and lips may be seen. Another occasional site for the disease is the back of the hands, the fingers, and the toes. The lesions in these different places are apt to be modified somewhat by the variations in the anatomy of the skin in the different regions. This is especially true of the scalp, where the characteristic red border is not well marked, and where the permanent loss of hair over the area of central atrophy is a predominating symptom.

Lupus erythematosus of the mucous membrane is ex-

tremely rare. It has been reported on the buccal surfaces, and also on the conjunctiva in connection with the disease on the skin of the face.

Many attempts have been made to establish subdivisions of the disease in accordance with the different lesions which may be present. The most important classification is that of Kaposi, who recognized two forms. One is the discoid, of which the butterfly lesion is a type, and the other is the disseminate form, in which the lesions are multiple and their evolution is more rapid, some undergoing involution and others persisting. In these cases there are apt to be grave constitutional disturbances of a typhoidal nature, with a fatal termination.

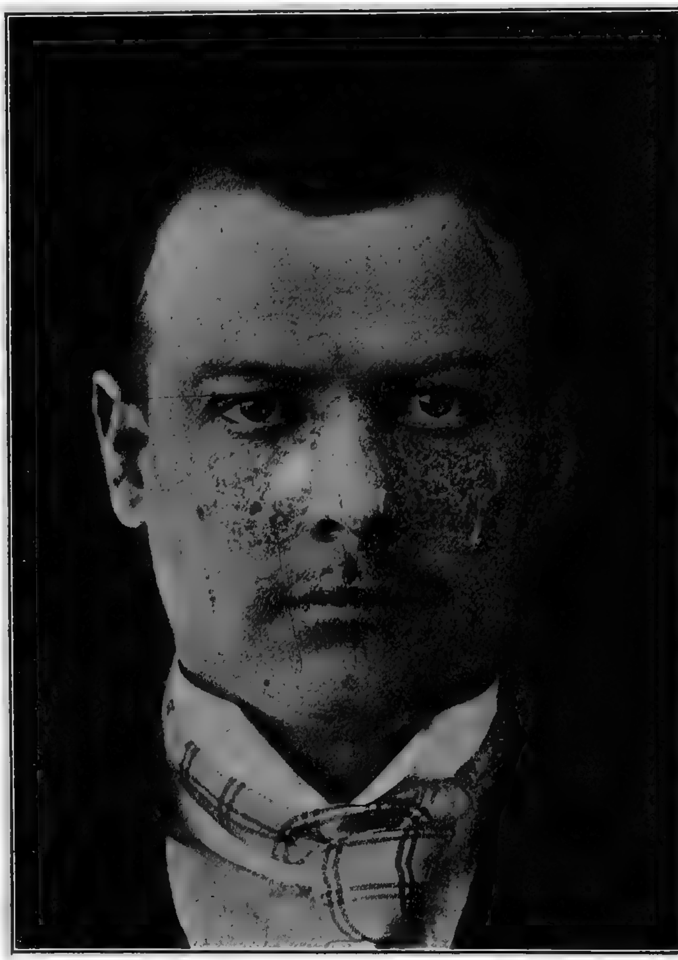

FIG. 3256.—Lupus Erythematosus. Typical butterfly lesion (Hebra) of the cheeks and nose, with accompanying involvement of the eyebrows and lips. (Fordyce.)

PATHOLOGICAL ANATOMY. — Although many important histological features of lupus erythematosus have been definitely settled, in general the results of microscopical research have not been satisfactory. While one can say with absolute certainty that neither the tubercle bacillus nor any other micro-organism is present in the lesions, the fact remains that, so far as parallels can be drawn, the sections of lupus erythematosus closely resemble those of other inflammatory processes. The earliest lesion and the advancing periphery of the patches show no other departure from the normal than the existence of a small round-cell infiltration in the neighborhood of and around the capillaries of the upper third of the corium. These cells are often confined to the perivascular lymph spaces, and the general consensus of opinion is that they are continually passing out from the blood stream. That the blood-vessels are in a chronic state of dilatation is of course known from the clinical aspects of the disease. The fate of these round cells is not always uniform. Many probably repass into the circulation unaltered; others undergo fatty degeneration or are changed into a finely granular material, and then probably remain *in situ*, in this altered condition, for long periods.

The cells themselves are always uninucleated, their nuclei staining with great brilliancy. Multinuclear leucocytes are practically not found. When degeneration occurs, it does not attack any special collection of cells, but affects the cells here and there. This is an important feature because, although large collections of cells are frequently found, there is no evidence at any point of the influence of a toxin acting locally and causing cell destruction.

Passing to the older lesion we see these same cells often massed together in the now greatly dilated lymph spaces, and single cells invading almost every tissue of the skin. They are found among the epithelia of the rete and of the hair follicles, in the sebaceous glands, between the muscle cells of the arrectors, and among the nerve fibres. The vessels are in many places thrombosed and filled with collections of cells and detritus. Another change, probably peculiar to lupus erythematosus and dating from the early lesion, is the degeneration of the collagenous bundle, so that in many places the whole mass of connective tissue in the corium gives a positive reaction with elastic fibre stains, such as acid orcein. The rete Malpighi is greatly thinned in all stages of the disease and the spinous processes are practically flattened out. The coil glands are often dilated and contain casts, in which case the mouth of the gland is found plugged with horny tissue.

In the oldest atrophic portion the infiltration is always less apparent, but more distant regions, like the fat bodies, are found to have their capillaries mantled by the same round cells. Here the larger vessels and nerves are often reduced to mere fibrous cords and are recognized with the greatest difficulty. Most of the sinking-in of the atrophic portion is due to the collapsing of the lymph and blood-vessels.

In summing up the results of the microscopical investigation, we can say to-day that in all probability the primary lesion of lupus erythematosus is a paralysis of the muscular support of the vascular system of the skin. The exudation of round cells is distinctly a passive one. The dilatation of the blood and lymph spaces is permanent and results in grave disturbances of the nutrition of the area. The subsequent atrophy is due to a great extent to the obstructive processes in the vessels and a cutting-off of the blood supply.

ETIOLOGY.—Lupus erythematosus is one of the rarer diseases of the skin. It is somewhat more common in women than in men. It is essentially a disease of adult life, although cases have been reported in which the process started in childhood and in old age. While the exact cause is unknown, certain predisposing local influences have been noted. These are, on the one hand, congestive disturbances of the skin, the disease following acne rosacea, eczema seborrhœicum, erysipelas, and scarlet fever; and, on the other hand, direct trauma or injury of the corium, by frost-bite, tattooing, insect stings, and instrumental treatment of other diseases with the scarifier

or curette. It must be admitted, however, that the disease usually starts without known antecedents, and, so far as can be detected, in perfectly healthy individuals. Many other troubles have been reported as being associated with the disease, but they do not throw any light on the nature of the affection. Among these are uterine derangements, chlorosis, anæmia, and chronic nephritis. Some writers mention a lack of mental development, and state that melancholia, induced by the disfigurement of the lesions, is not uncommon.

The question of the relationship of lupus erythematosus to tuberculosis, while still kept open by the French school of dermatologists, has ceased to excite the same interest which it did ten years ago. Briefly, it may be said that the International Congress of Medicine, held in Paris in 1900, did not settle this point. At that time the microscope had furnished sufficient negative evidence, as regards the existence of the tubercle bacillus in the lesion of lupus erythematosus, to warrant the declaration that it was absent. The French school, however, claimed that the absence of the bacillus could not exclude tuberculosis altogether, for they had been able to detect true tuberculous deposits in other parts of the body in a sufficient percentage of cases to warrant a legitimate suspicion as regards the remainder; and consequently they held that this disease, as well as many others, was due to the circulation in the blood of the toxin of the bacillus, which, acting on the vaso-motor centres, was capable of causing the lesions. Diseases in this group are called "toxi-tuberculides," in contradistinction to true tuberculosis of the skin, in which the bacillus can be demonstrated. The group of toxi-tuberculides is a large one and embraces certain necrotic papular affections in which not only does there seem to be more evidence of the local action of a toxin than we have in lupus erythematosus, but in which there is also a greater percentage of known tuberculous subjects. The opponents of the French school have failed to find in their cases the same high percentage of tuberculous patients, and hence do not recognize any necessary connection between the two diseases.

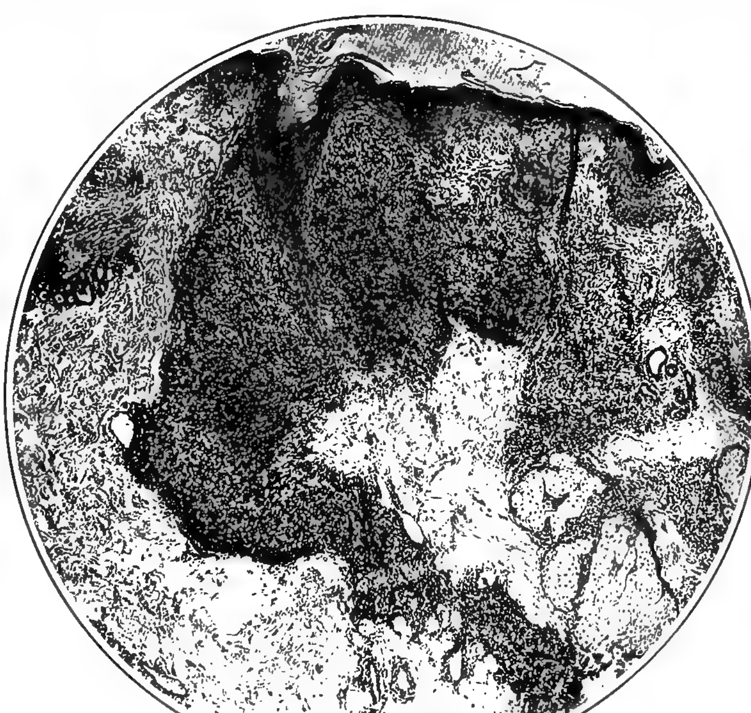

FIG. 3257.—Lupus Erythematosus of the Cheek, at the Height of the Erythema. The section shows an extensive focus of infiltration, with two open capillaries; a plug in orifice of sweat duct; only slight atrophy of epidermis. (Fordyce.)

DIAGNOSIS.—Typical cases of lupus erythematosus do not present any great difficulty of diagnosis, but in the various stages of its evolution certain points of resemblance to other dermatoses may be a cause of confusion. This is especially the case when we are in the presence of an early lesion, covered more or less with scales, and when the atrophic nature of the process is not in evidence. Here we must exclude nearly all of the superficial scaly diseases before making a diagnosis. The late lesions, especially those of the face, sometimes offer difficulties in diagnosis. Here the patches may at times resemble those of lupus vulgaris or of syphilis in the tertiary stage. Both these classes require special consideration, but the latter is the more important and will therefore be taken up first.

The late lesion is most often confounded with lupus vulgaris, especially in those cases in which true tubercles of lupus vulgaris have developed at some part of the lesion. In these cases the fact that lupus erythematosus never ulcerates or attacks the deeper tissue, as does lupus vulgaris, is perhaps the most important point in differentiation; but the patulous sebaceous follicles, the peculiar scale formation, and the appearance of the central atrophy in lupus erythematosus, which has little resemblance to the scars left by an extensive lesion of lupus vulgaris, are also important. In cases of the uncomplicated lesion of lupus erythematosus, the absence of the typical subcutaneous tubercle of lupus vulgaris renders confusion impossible.

From the serpiginous syphilide of the face, lupus erythematosus can be differentiated by its much slower evolution and by the absence of scar tissue. Furthermore, the tertiary lesions of syphilis show a tendency to extend by the formation of distinct foci and not by the even marginal progression of lupus erythematosus. If any uncertainty should exist, the history of the patient and the positive results of anti-syphilitic treatment would clear up the diagnosis.

From discrete patches of eczema and psoriasis lupus erythematosus can best be differentiated by a close examination of the skin after the forcible removal of the scales. Neither of the two processes ever ends in an atrophy of the skin, nor do they show the extension of the scale formation into the mouths of the sebaceous glands. On the other hand, the pathognomonic sign of psoriasis, which appears on the tearing off of its scales and consists in the opening of the finger-and-toe processes of the corium as bleeding points, is never seen in connection with lupus erythematosus. Further points of differentiation from eczema are that the history of both moisture and itching is rarely absent in eczema, and, besides, the border line between eczema and the healthy skin is not so sharply marked as that in lupus erythematosus.

From tinea tricophytina, lupus erythematosus can be differentiated by the facts that the lesion starts at a late period of life, and that the microscope does not reveal the presence of mycelium and spores.

PROGNOSIS.—The prognosis of lupus erythematosus is

good as regards both the general health and the outcome of any rational treatment. The chances of tuberculosis of the lung developing are slight, but should be borne in mind. Small patches offer an excellent opportunity for removal, and the larger superficial lesions usually yield to mild treatment. Even the much raised discoid lesions often disappear of themselves. The two unfavorable features of the disease are its tendency to relapse and the amount of time required for treatment. An exception to a favorable prognosis is in the acute type of Kaposi. This is very rare and but one case has been reported in the United States.

TREATMENT.—While there are no known internal remedies that have a specific influence on the lesions of lupus erythematosus, a careful survey of the general condition of the patient is most desirable. A tonic or antituberculous treatment is often indicated. Articles of food and drink which cause a temporary flushing of the face should be avoided, and the patient should be instructed to guard as far as possible against the extremes of heat and cold. A number of observers have from time to time reported the amelioration of the trouble during the administration of certain remedies. Among them are the iodide of potassium, iodoform, arsenic, ichthyol, and the salicylate of sodium.

The external treatment is of great importance and, for convenient consideration, may be divided into the following sections: (1) The application of soothing remedies; (2) the use of stimulating applications; (3) surgical interference.

Soothing remedies are always indicated when there is much hyperæmia of the skin. Small young lesions frequently disappear under this treatment alone. It is also useful when the lesions show unusual vascularity or a tendency toward inflammation, and as an after-treatment when the skin has been artificially stimulated in the course of treatment. The soothing preparations employed are astringent powders, lotions, and simple ointment, such as are recommended for the treatment of acute dermatitis. Powders containing oxide of zinc and the common washes of zinc and calamine are much used. Compression obtained by the application of collodion and ichthyol or by strapping the lesions with zinc oxide plaster is sometimes beneficial.

Of the many stimulating remedies the most useful is the tincture of green soap. This is applied daily by rubbing well into the patch and then washing with water. A slight grade of inflammation is set up, which in turn can be treated by some soothing lotion. This treatment is especially applicable in lesions with excessive scaling of the follicles. By it the plugs in the sebaceous glands are removed and a great improvement in the appearance of the lesions on the face can be obtained. Care should be taken that the applications are not too prolonged or too severe, for the epidermis over the patches is extremely thin and sensitive. After the scales and plugs are removed, they can often be kept away by the application of Lassar's paste containing salicylic acid. Other preparations of value in this class are ointments containing sulphur, tar, oil of cade, mercury, ichthyol, and resorcin. Cases have been reported as cured under the continuous application of mercurial plaster. In very indolent patches painting with pure carbolic acid or with glycerin in which iodine and iodide of potassium are dissolved has been found beneficial.

The treatment by caustic acids and alkalies is obsolete, having been discarded on account of the excessive destruction of tissue. Some writers, however, recommend the acid nitrate of mercury, arsenic paste, and chloracetic and pyrogallic acids. Only very small areas should be treated at a time if these remedies are used.

Treatment by surgical means is often useful, especially the method of linear scarification. This does not differ in any way from the same method used in acne rosacea or in lupus vulgaris. It consists in making parallel cuts through the patch and carrying them a short distance outside it, and then in making another set at right angles to the first. Bleeding should be encouraged and pressure made if the patch is much raised. This treatment is not difficult and gives exceedingly good cosmetic effects. Other methods are: curetting the tissue away *en masse*, and destroying it by the electric cautery. Neither is of much value. During the past few years cures have been made by both radio- and phototherapy.

Oscar H. Holder.

LUPUS VULGARIS.—Lupus vulgaris is a cellular new growth of the skin or mucous membrane due to the direct inoculation with the tubercle bacillus and to the peculiar formative reaction of the connective tissue which follows the infection. Neither histologically nor in respect of its intensely chronic course does this form of tuberculosis of the skin differ from the chronic form of tuberculosis situated in other parts of the body, and hence, as elsewhere in tuberculosis, the lesion of lupus vulgaris starts by the development of typical tuberculous tissue. This primary efflorescence, or lupoma, consists of several brownish-red to yellow areas, from the size of a pinhead to that of a pea, situated in the deeper parts of the corium, and, when uncomplicated by secondary changes in the skin, the lesion is easily recognized by its peculiar characteristics. The nodules are deeply seated in the skin and cause no apparent tumefaction. When pressed upon with a piece of glass, they lose their redness and become either brown or yellow, a color due to necrobiotic changes at the centre of the nodule. In consistency they are much softer than the surrounding skin and are easily penetrated by any fine blunt-pointed instrument. The evolution of the nodules is extremely slow, but in time they always disappear by absorption, leaving scar tissue. The disease itself spreads by the formation of new foci at the periphery and by invading the deeper tissues. The disease on the face seems to have a special predilection for cartilage, as that of the nose.

While many lesions of lupus pursue an uninterrupted course to the formation of a cicatrix, others are markedly modified by secondary changes which occur in and around the nodule and in the overlying epidermis. The varying degree of involvement of the corium and of these secondary changes may give to lupus a great number of clinical pictures, and it has been the custom to subdivide the disease by the addition of Latin adjectives, which merely designate the chief clinical feature present. The more important are as follows:

Lupus maculosus (Lupus planus.)—This division embraces all lesions of lupus vulgaris which consist of the uncomplicated efflorescence of the nodules. The disease begins by the appearance of only a few tubercles, but before many months have elapsed the end product is apparent as scar tissue. This scar tissue is very diffuse and even, for the tubercles occupy the whole depth of the corium and have little or no healthy tissue between them. The disintegration and resorption of the tubercle, on the other hand, do not always take place in a uniform manner. Although the scar tissue is situated in the main at the periphery of the lesions, it rarely happens that the central area of a lupus scar is so entirely separated from them that pressure with glass does not reveal their presence in a partially absorbed state. Their existence in some part of the lesion is not only necessary for diagnostic purposes, but it affords a measure of the activity of the process at any local point, as regards both the invasion of the adjacent healthy skin and the likelihood of further development at the centre of the lesion.

In this group must be included lupus vulgaris when it is developing in the lesion of other diseases, as lupus erythematosus, and in old scars, and it is usually the condition in which the disease primarily appears when the other forms are to be the ultimate product.

Lupus nodosus (L. tuberculatus, elevatus, tumidus, non-exegens, non-ulceratus).—This clinical type follows the macular variety and is due to the tendency of the individual nodules to remain *in situ* unchanged. The formation of new granulomatous foci predominates and the skin is elevated into a mass of papules and tubercles. This form pursues a remarkably slow course, but rarely

ulcerates. Sooner or later the involution of the lupus tissues begins and terminates in the formation of a thick and uneven cicatrix.

Lupus exulcerans (L. crustosus, rodens).—This division includes the moist patches of lupus. The overlying epidermis loses its protecting character and allows the lupomata to be exposed to external influences. In the milder cases an impetiginous or eczematous condition may be present, with the formation of crusts and scales, or the epidermis may be entirely destroyed and a true ulcer result.

These lupus ulcers, owing to their resemblance to certain forms of syphilis and epithelioma, are sometimes difficult to diagnose. They may be covered with crusts or their floor may be the seat of an exuberant outgrowth of granulations. Their border is the most characteristic feature, and it is there that the signs upon which a diagnosis may be formulated are most evident. Owing to the extremely slow and irregular necrosis of the lupomata, this border is irregular, non-elevated, and soft, and the individual lesions are usually visible.

Lupus serpiginosus.—This name is given to those lesions which have a tendency to rapid extension at the periphery. The lupomata evolve completely into cicatricial tissue, and we have, as a result, superficial scars of great size which show few or no nodules in the centre but many at the periphery. This group embraces the most disfiguring cases that are seen on the face and scalp and which are extremely rebellious to treatment. This form is also common on the arms and legs.

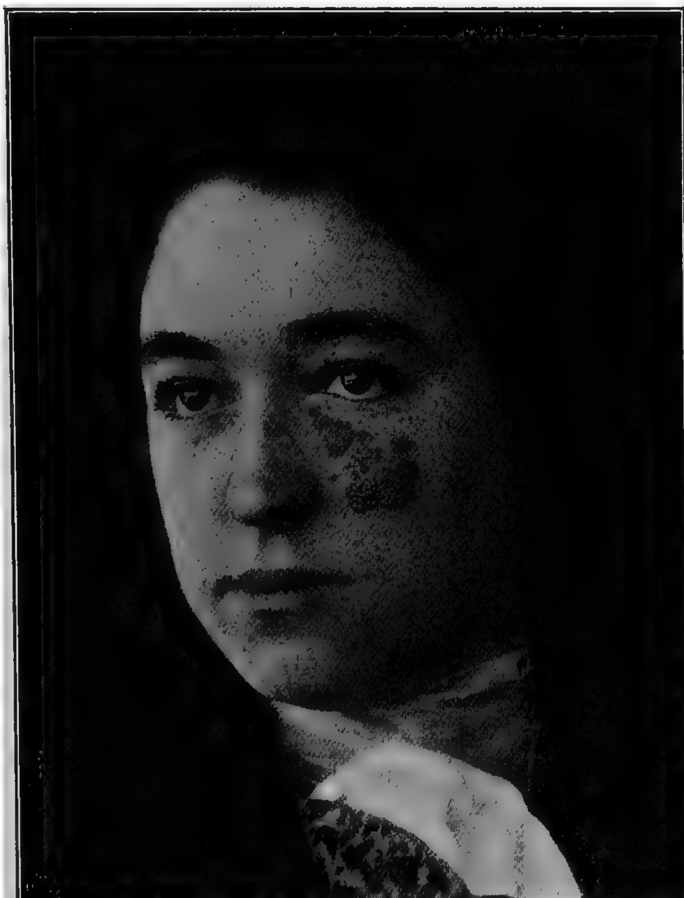

FIG. 3258.—Lupus Vulgaris (six years' duration). The type is that of a young macular lupus, with a tendency to epithelial hypertrophy. (Fordyce.)

Lupus hypertrophicus.—In this type of the disease an exuberant growth of connective tissue entirely overbalances other tendencies and the lesion becomes covered with soft exuberant granulations which bleed very easily. This form is most often seen following the ulcerated lesions on the nose. In these cases the granulations are not covered with epithelium, nor do they contain the tubercle bacillus or the lupoma. They must be looked upon as the results of secondary infection, for a similar condition appears in connection with syphilitic and other ulcerations. The name hypertrophic is also applied to cases in which epithelial hypertrophy appears. This may be present in very small lesions and consists in the development of verrucous growth above the level of the lupoma. In certain cases, in which the disease is located on the leg, the growth may be so excessive as to produce an appearance like elephantiasis.

Lupus of the Face.—The face is the most frequent seat of lupus, and here every form of the disease appears. It has been supposed that infection often takes place through the lymph channels of the nostrils, but it is more likely that the peculiar anatomy of the skin of Hutchinson's flush area has more to do with the determination of this frequency. The area of the nose is undoubtedly the starting-point in most cases, and, as Besnier has asserted, the disease is accompanied and often preceded by an obstinate crusting inside the nostrils. Often it happens that before the disease has spread beyond the region of the nose, serious involvement and destruction of the nasal cartilages has taken place. This may not be evident during the earlier stages of the disease, for the nodular and hyperplastic types of lupus are usually present, and the crust and outgrowth of granulation tissue are apt to cover up the extent of the destruction. When the cicatrix is formed, however, the loss of cartilage is apparent even when the lesion has been a very small one. After an extensive lesion of the nose, the resulting deformity is distinctive, giving to the nose a peculiar lopped-off appearance. Contrary to what happens in syphilis, the nasal bones remain intact, this fact being an important means of distinction between the two diseases.

Lupus of the Upper and Lower Lip.—This region may be the primary seat of lupus, but is more often involved in the extension of the disease from the nose and cheeks. The lips early become greatly swollen, deeply fissured and crusted, and they bleed easily. Extension to the inside of the mouth is invariable, and in this locality the disease shows itself by the usual manifestations of lupus of the mucous membrane. The deformity caused by the cicatrization is extreme. The mouth is greatly reduced in size and the jaw is practically ankylosed by the tightness of the scar.

Lupus of the Auricle.—This may be primary or secondary to a lupus of the face. It is sometimes symmetrical, but usually one ear alone is affected. The process sometimes starts in the lobular region where the changes are most characteristic. Owing to the looseness of the connective tissue of the lobules there is great swelling of this part of the ear, and the lobule hangs down as a purplish pear-shaped tumor from the much hypertrophied auricle. The skin is very thin and transparent, and is apt to be in an eczematous state. The process ends in the entire destruction of the auricle, the scar sometimes completely occluding the external auditory meatus. Extension into

the auditory canal is common. Cases have been reported in which the membrana tympani was ruptured.

Lupus of the Extremities.—This is, next to the face, the most common region for the development of lupus. The lesions are especially important in that they sometimes attain a great size, and, through the contraction of their resulting scars, they may cause a loss of movement in the joints. Most of the lesions are situated on the forearm or lower leg, where the natural thinness of the skin is prone to cause a serpiginous form of the disease. Secondary extension to the deeper tissue is not uncommon, and in turn the fascia, tendons, periosteum, and bone may be so involved that the limb requires amputation. Besides the limitation of movement in the knee and elbow, another troublesome sequela of cicatricial contraction is the pressure on the veins. The limb becomes very œdematous and the process ends in a state of elephantiasis, for which there is no amelioration except by amputation.

FIG. 3259.—Lupus Vulgaris (twenty-five years' duration). Extensive cicatrix, showing activity in temporal region. The destruction of the lobule and cartilage of the auricle is characteristic. (Fordyce.)

Lupus of the Genitalia. — Primary lupus of the genitals has been reported in both males and females, but is of great rarity. Hebra reported one case on the penis. In the female, the vulvar and anal regions are sometimes attacked by the ulcerative forms of the disease, and the cicatricial contractions result in great disfigurement of the parts.

Formerly lupus of the female genitals was considered more common than it is to-day. Under the name of "esthiomène" many cases were reported in France. It was then believed that lupus of the vulva presented characteristics not common to the disease in other parts of the body. The researches of Dr. Robert W. Taylor, of New York, on this subject led him to conclude that in many of these early cases the disease was not true lupus but the result of a number of causes, among them syphilis, chancroids, traumatism, and filth, and that tuberculosis, when it did invade this region, was not unlike the same disease of the skin elsewhere.

Lupus of the Mucous Membranes.—Lupus has been known to develop primarily on the mucous membrane of the nose, lips, gums, tongue, hard and soft palate, and larynx, but in the great majority of cases it is secondary to tuberculosis elsewhere, and the result of direct extension of a facial lupus. In place of the lupous nodule there appear small papillary excrescences, closely packed together in plaques. These are whitish in color from the excessive growth of epithelium above the infected area. They are favorably situated, owing to warmth and moisture, for undergoing superficial ulcerative changes. They terminate in scar tissue in all cases.

PATHOLOGY.—At the present day there is no longer any doubt existing in the minds of the great majority of observers that lupus is a tuberculosis of the skin, and that the microscope must show evidences of this specific infection when an absolute diagnosis is required. Strange to say, the practical demonstration of lupus in the laboratory does not always consist in the finding of the tubercle bacillus. Owing to the great scarcity of these organisms in the lesions and the complicated differential stain that they require, it happens that failures in this regard are frequent, if not usual. Fortunately, the appearance of the essential clinical lesion, the lupoma, is sufficiently characteristic to be unmistakable. This consists of an area in the corium composed of a number of small round cells with deeply staining nuclei, a larger type of cells—called epithelioid cells — containing one or two nuclei at their periphery, and near the centre of the area a third type of cell known under the name of Langhans' giant cell. A fine network of connective tissue passes around and through this collection of cells. Specific stains show that in these areas the collagenous bundles and elastic fibres are either absent or greatly rarefied, while at the periphery both of these normal elements of the corium are plainly visible. The reason for this is believed to be that by the slow growth of the lupoma these tissues are laterally displaced rather than absorbed, and that they form a fairly impervious wall, which has a greater or lesser tendency to contract and compress the cellular area in the centre. Later, this compression manifests itself by the necrobiotic changes which occur in the older lupomata. In these a coagulation necrosis or cheesy degeneration commencing at the centre and extending outward results, proliferation of new connective tissue from the periphery penetrates into and replaces the necrosed lupoma, and scar tissue is the final product.

An unusual exception to this reticulated granuloma, that is usually found in lupus, may occur. Instead of being confined by the connective-tissue wall, the tuberculous areas are small and distant from one another. The groups of cells are rather in the form of an infiltration in the corium, but they do not differ histologically from those found in the common type. The giant cells

EXPLANATION OF
PLATE XLI.

EXPLANATION OF PLATE XLI.

Extensive Lupus of the Face, of Fifteen Years' Duration. The following lesions are recognizable in the picture: Destruction of the nasal cartilage; loss of lobule of the auricle; ectropion of the eye from contraction of cicatrix; and fissured condition of the lips and chin.

(This picture and those which appear in the body of the text of both articles—lupus erythematosus and lupus vulgaris—are from the collection of Dr. John A. Fordyce, of New York.)

LUPUS VULGARIS OF TWENTY YEARS' DURATION

(FROM DR. JOHN A. FORDYCE'S COLLECTION OF PHOTOGRAPHS OF SKIN AFFECTIONS)

are always present and these are the chief guide to diagnosis. As Unna points out, these cases are apt to extend rapidly, and have a tendency to epithelial hypertrophy. The lesions are apt to be extremely hyperæmic and may not show the presence of the lupoma at all. They are sometimes difficult to tell from lupus erythematosus, and histologically are allied to tuberculosis verrucosa cutis.

In the secondary changes to which lupus is prone, corresponding histological variations occur, but they are of little importance beyond the fact that care has to be exercised in order to obtain excised specimens that will contain the lupus tissue. In the verrucous and hypertrophic forms this tissue lies far below the surface of the warty development.

Diagnosis.—In spite of the multiformity of the clinical pictures presented by lupus vulgaris, the essential characteristics of the disease are so marked that a diagnosis in most cases is easily made. A history of the patient reveals almost invariably that the disease dates from childhood and that it has pursued a most chronic course. The examinations of the lesion rarely fail to show at some point the small primary granuloma, the soft consistency of which and its appearance when pressed on with a glass slide are pathognomonic. The diseases most apt to be confounded with lupus are tertiary syphilis, lupus erythematosus, and epithelioma.

From *syphilis* in its tertiary stage a differential diagnosis has often to be made in two quite different cases. The non-ulcerative serpiginous syphilide resembles to a great extent the non-ulcerative form of lupus, and the deep ulcerating syphilide has many of the appearances of an ulcerating lupus. The non-ulcerative syphilide, developing in the form of a subcutaneous gumma, presents tubercles which, while they have much resemblance to the tubercles of an elevated lupus, attain their size much more rapidly, are harder, rounder, and of a copper color. Furthermore, in syphilis we usually have a multiplicity of lesions; in lupus, more often only one. Lupus starts before puberty, while an acquired syphilis belongs to adult life.

In the ulcerative forms of syphilis the ulcer is usually round, its edges are sharply cut and everted, and its discharges more copious than in lupus. This is due to the nature of the neoplasm, in which the softening of the gumma causes a much greater loss of tissue than does the slow necrosis of a lupus lesion, which presents a much more superficial ulcer, whose edges are irregular and non-everted. On the other hand, the lupus scars form at a slower rate, are deeper, and cause more deformity than the syphilitic.

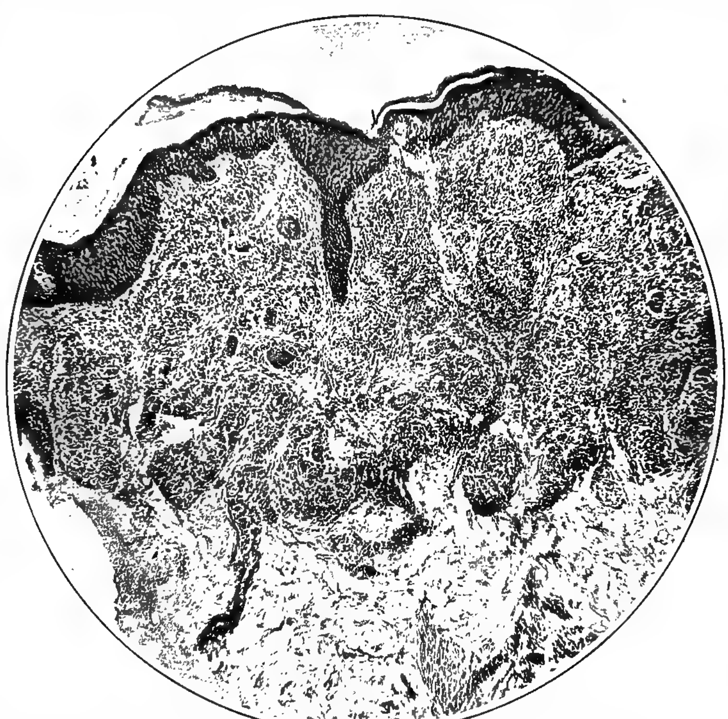

Fig. 3260.—Section of Lupus Vulgaris of the Cheek. The reticulated nature of the neoplasm is evident. Good examples of giant cells. (Fordyce.)

From *rodent ulcer* an ulcerating lupus can be told by the margin of the epithelioma. This is hard, elevated, pearly-white in color. The ulcer is deeper and its floor has no tendency to form healthy skin. Epithelioma begins in advanced life, and its course is usually associated with more or less pain. The lupus ulcer, on the contrary, presents no such margin, is painless, and has a tendency to heal.

Lupus erythematosus is distinguished from lupus vulgaris in that the former begins after puberty and advances by an even, raised, erythematous border and not by the formation of subcutaneous granulomata. It never ulcerates and does not form contracting scars. The peculiar scaliness and the involvement of the sebaceous glands in lupus erythematosus are not seen in lupus vulgaris.

Acne rosacea may at times resemble lupus on account of the tumefaction of the nose, which appears in both diseases, but its history, the intense hardness of the fibrous tissue, and the presence of the dilated capillaries should distinguish it from the disease under consideration.

Prognosis.—The prognosis of lupus vulgaris would not be unfavorable if it were not for the uncertainty as regards recurrence. The destruction and removal of the tuberculous nodules and hypertrophic tissue are not difficult, but it can never be said that the resulting scar does not contain sufficient infective material to cause a fresh outbreak of the disease. Especially is this true of the cicatrix left by lupus maculosus when the nodules are so deeply embedded in the fibrous tissue that they are not visible to the eye. Lupus is not often seen in connection with general or pulmonary tuberculosis, yet cases have been reported in which death has resulted from the spreading of the affection to the lungs or from the development of acute miliary tuberculosis.

Treatment.—The treatment of lupus vulgaris may be divided into (1) constitutional and (2) local.

Constitutional Treatment.—The care of the general health, good food, fresh air and sunlight, and a life out of doors will benefit the patient more than the internal administration of remedies. In the past many methods of treatment have been recommended for the tuberculous, and nearly all of them in turn have found a serious stumbling-block in lupus vulgaris. In this disease the superior opportunity for observation allows of a final decision on the question of their efficacy, and the admission must be made that modern dermatology has received little from the therapeutics of pulmonary tuberculosis that it has not been obliged to condemn. No remedies have any influence on the rate of extension of lupus, nor do they hasten the necrosis and absorption of the lupomata.

Only so far as the state of the general health or an impaired nutrition may be benefited are internal medicines indicated. With this sole purpose in view may be tried cod-liver oil, chalybeates, and tonics, care being taken that the deleterious action on digestion does not exceed the benefit derived. Of other remedies recommended, but of doubtful value, may also be mentioned iodide of potassium, iodoform, quinine, arsenic, creosote, and chloride of calcium.

Local Treatment.—This consists in the destruction and removal of the lupomata with as little disfigurement as possible. In making a selection of the most suitable means to this end, the variety of the disease must be taken into careful consideration.

In the case of small lesions the ideal treatment is excision with or without a Thiersch's skin graft. The results, when this method is successful, are most satisfactory, but unfortunatetly the number of selected cases in which it is applicable is small, and the reports show that recurrences are by no means unknown.

If there is no chance to extirpate the lesion, the best results are obtained either by curetting or by the use of the scarifier. In curetting, as much as possible of the soft tissue is scraped away and usually some caustic is subsequently applied. The lesion is allowed to cicatrize, after which the curetting can again be repeated if it is found necessary. Dr. G. H. Fox has devised a method for removing the nodules, when they are deeply situated, by means of the dental burr. This penetrates the meshes of the scars, and undoubtedly reaches small granulation areas that the dermal curette would not enter. Other instruments have been contrived for the same purpose. Curettage meets the indications best in case of a rapidly advancing margin, in ulcerated cases, with or without hypertrophic outgrowths, and in cases with recurrence. If large areas are to be treated, a local or general anæsthetic should be employed. The worst hindrance to the operation is the impenetrability of the scar tissue and hence the difficulty of getting at the deeply situated lupomata.

Linear Scarification.—This method was proposed by Volkmann and afterward modified by Vidal and others. Parallel cuts, about one-tenth of an inch apart, are made by a sharp knife through the lupous tissue. Many special instruments have been invented for scarification, that devised by Vidal himself having two cutting edges. The knife has to be very sharp and is held like a pen, the strokes being rapidly made. The depth to which the cuts penetrate can be easily regulated after a little practice. Free bleeding is encouraged, and when it has been checked a little, other cuts at angles of from 60° to 90° to the first set are made. This operation is not painful and requires no anæsthetic. It should be repeated every six to eight days until the desired result is obtained. Here again the operation is not possible in badly sclerosed cases, but is specially applicable in cases showing much vascularity and on the border of a lupous ulcer.

Other methods entailing surgical interference are by cauterization with the thermo-cautery or with the electrocautery. Besnier, to whom the perfection of the operation with the galvano-cautery is due, has invented a number of special cautery points suited for both superficial and deep application. Small lesions are riddled with punctures and then allowed to heal up. This method is also to be recommended for the destruction of small inaccessible lupomata and of small areas of granulations.

Of the medicinal means employed for the treatment of lupus many are still extant, but most have been superseded by the surer methods of instrumentation. Formerly, caustic applications were extremely popular. Among them the treatment by the solid stick of nitrate of silver still survives. The stick is pushed into the soft tissue and a mechanical as well as caustic effect is produced. This gives good results in small and discrete patches. Vienna paste containing white arsenic and cinnabar is also used to-day. The application is very painful and has to be kept up for two or three days. The amount of destruction of the lupous tissue is considerable, but the healthy tissue is for the greater part spared.

Another method of directly destroying the lupomata is that recommended by Unna. This consists in preparing small splinters of wood by soaking in a solution of carbolic acid and corrosive sublimate, and then driving them directly into the lupomata, where they are held in place by plasters and allowed to ulcerate out. Pledgets of cotton may be used for the same purpose. Other writers have advised various liquids to be injected into the tissue or sprayed or painted on the surface. With the object of macerating the epidermis and exposing the lupomata, many ointments and other preparations are used. At the head of these probably stands the salicylic-acid plaster. After its use stronger and more destructive applications should be employed.

Lately, there have come to the front in the treatment of lupus two entirely new methods which bid fair to be *the* treatment of the future. The first, devised by Professor Finsen, of Copenhagen, consists in the concentration of sunlight or the arc light, by a system of lenses, directly on the lupous patches. In this light the heat and red rays are cut off by water chambers, and as far as possible the ultra-violet and chemical rays alone are used. These rays are believed to have powerful bactericidal qualities and the power of penetrating the skin. The second method is now more universally used and consists in the application of the *x*-rays. Both these methods have been reported as affording excellent results, although they are not invariable. One of the great advantages which they both possess is the small amount of scarring that remains after a cure. The disadvantages are the expense and long time required for treatment.

Oscar H. Holder.

LYCETOL.—Dimethyl piperazin tartrate $[NH(CH_2CHCH_3)_2NH + H_2C_4H_4O_6]$—is obtained by distilling glycerin with ammonium bromide and reducing the dimethyl pyrazin thus formed with metallic sodium. It is a white, odorless powder with acid taste and reaction, and is readily soluble in water. Like piperazin this salt is a solvent for uric acid, and is used in cases of gouty diathesis. Wiltzack reports considerable diuresis, the urine having a low specific gravity, non-occurrence of an otherwise regularly recurring attack of gout, and diminution of gravel when the remedy was continued a long time. Hamonic found it to improve the urine in purulent cystitis. The dose is 1–2 gm. (gr. xv.–xxx.) dissolved in plenty of water, its lemonade-like taste making of it a pleasant drink.

W. A. Bastedo.

LYCOPODIUM.—*Vegetable Sulphur.* "The spores of *Lycopodium clavatum* L. and of other species of *Lycopodium* (fam. *Lycopodiaceæ*)," U. S. P. These plants are evergreen creepers, common throughout the north temperate zone. Their ament-like spikes bear numerous sporangia. These spikes are collected, chiefly in Northern Europe, dried, and threshed. Considerable dirt is inevitable, and this amount is frequently largely increased for purposes of adulteration; hence the necessity for estimating the amount of ash, and for microscopical examination. The following is the official description:

"A fine powder, pale yellowish, very mobile, inodorous, tasteless, floating upon water and not wetted by it, but sinking on being boiled with it, and burning quickly when thrown into a flame. Under the microscope the spores are seen to be sphæro-tetrahedral, the surfaces marked with reticulated ridges, and the edges beset with short projections.

"Lycopodium should be free from pollen, starch, sand, and other impurities, any of which are easily detected by means of the microscope.

"When ignited with free access of air, lycopodium should not leave more than five per cent. of ash."

It contains forty-seven per cent. of fixed oil (Flückiger), and has no other important constituent. It is used only

as a non-adhesive powder for the protection of moist pills from sticking together, and for dusting upon excoriated

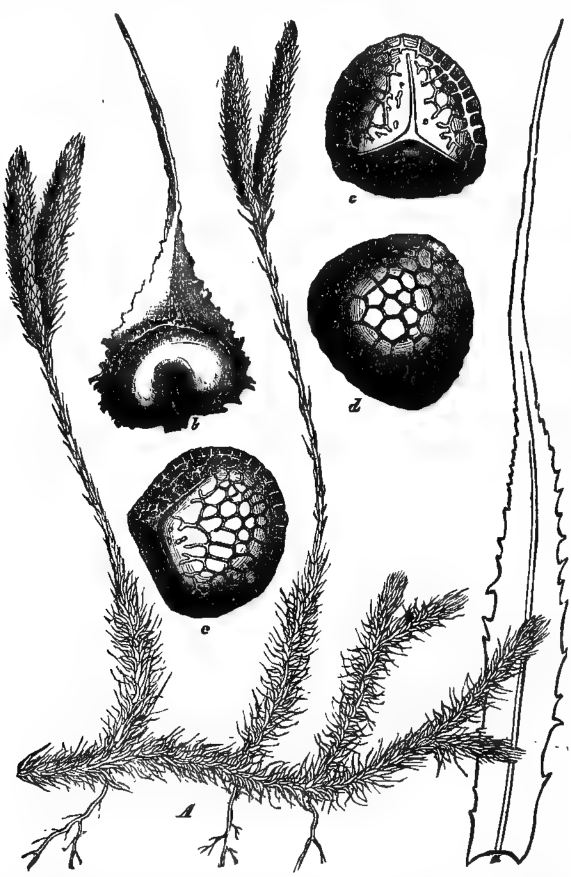

FIG. 3261.—Lycopodium Plant and Spores. *A* is the plant, something less than natural size; *a*, one of the leaves, enlarged; *b*, a scale of the spike with the sporangium at the base, enlarged; *c*, *d*, *e*, different views of the spores. (Luerssen.)

places—to protect the surface and to prevent chafing; its action in both cases is wholly mechanical.

Henry H. Rusby.

LYMPH.—1. DEFINITION.—Lymph is one of the circulating fluids of the body. It is the all-pervading fluid of the body. It has been said that the higher animals as well as the lower are really aquatic, inasmuch as each cell of a reptile, bird, or mammal lives in a liquid medium—the lymph.

Blood comes into contact with the endothelial cells of the blood circulatory system, and with the cells within the spleen pulp—with these cells and with these alone. But these cells comprise a vanishingly small proportion of the cells of the body. All the rest of the cells—and that is, nearly all of the cells of the body—never come into immediate contact with the blood. They receive their food and their respiratory oxygen through the lymph; while the lymph in turn receives these materials for the sustenance of the cells from the blood.

On the other hand, waste matters, which are constantly forming within active cells, are thrown out of the cells into the lymph and make their way directly or indirectly back into the blood, to be carried to some excretory organ.

The lymph is thus the liquid medium of interchange between the living, active cells of the body (endothelium excepted) and the blood.

The way in which this interchange between blood and lymph, and between lymph and cells, takes place will be discussed under Relation of Lymph to Metabolism (section 5).

2. CLASSIFICATION.—The word lymph is frequently used with a somewhat wider meaning than that given in the definition above. In this wider significance lymph includes not only the lymph in the intercellular spaces but also all liquid, not blood, contained within endothelial-lined cavities or circulating within enthothelial-lined vessels. This more general definition includes the fluid contents of the pleural, peritoneal, and pericardial cavities.

It includes the chyle together with the contents of all lymphatics and lymph spaces.

The aqueous humor of the eye, the cerebro-spinal fluid and the synovial fluid, are closely related to lymph, but differ in certain important properties characteristic of lymph and may not be classed with lymph proper.

Lymph may thus be classified as:

I. *Tissue Lymph* — filling the intercellular spaces throughout the body.

II. *Circulating Lymph*—flowing along the lymph radicles and lymphatics, making its way slowly back to the circulatory system, usually viâ the thoracic duct.

III. *Chyle*—the circulating lymph of the intestinal mucosa and submucosa plus the food-stuffs (mostly fats) absorbed from the lumen of the intestine.

IV. *Serous Lymph*—the contents of the serous cavities.

3. COMPOSITION.—Tissue lymph, circulating lymph, and serous lymph have practically the same composition, as follows:

					Per cent.
Lymph.	Water				95.20
	Solids.	Organic.	Proteids		3.75
			Corpuscles.		
			Serum globulin.		
			Serum albumin.		
			Extractives		.10
			Fats.		
			Lecithin.		
			Cholesterin.		
			Sugar, dextrose		.10
		Inorganic.	Sodium chloride	0.56	.85
			Sodium carbonate	.24	
			Other salts	.05	
			Chlorides, sulphates, phosphates, and carbonates of Na, K, Ca, and Mg.		
					100.00

The proteids of lymph are contained partly in the corpuscles and partly in solution in the lymph plasma. An important constituent of lymph proteid is the fibrinogen—one of the globulins—which is one of the factors in the formation of the clot when lymph escapes from tissues or vessels. All lymph contains fibrinogen; but serous lymph contains no fibrin ferment and will, therefore, not coagulate spontaneously. The serous lymph contains less proteid (about 2.42 per cent.) than tissue or circulating lymph.

The salts of the lymph are the same qualitatively as those of the blood, differing only in their quantitative relations. The proportion of salts of the lymph is less than that of the blood.

Besides the above-enumerated constituents the tissue and circulating lymph contains small and indeterminate quantities of katabolites, chief of which is urea, which is found in amounts approximating 0.016 per cent.

Chyle differs from other forms of lymph in the large admixture of food-stuffs just absorbed from the alimentary canal. Practically all of the fat is absorbed into the lymphatics of the intestinal mucosa and submucosa. It circulates in these in the form of an emulsion. This gives the lymph, otherwise clear and light yellow, the appearance of milk, and called forth from Asellius,[1] the discoverer of the vessels which contain it, the name *lacteals.*

The amount of fat which the chyle contains will vary naturally with the conditions of the observation. If the observation be made upon a dog about two or three hours after a meal rich in fats the lacteals will be found gorged with a chyle as white as milk and very rich in fats. If, however, the observation be made under condi-

tions in which the lymphatics in question are not carrying absorbed fats, the vessels do not differ in appearance from other lymph vessels, and the contained chyle would not differ essentially from circulating lymph in its chemical composition.

Chemical analysis shows the chyle, when drawn from the lacteals after a meal rich in fats, to have the following composition:

				Per cent.
Chyle.	Water			90.67
	Solids.	Organic.	Proteids	2.21
			Extractives—Fat	4.71
			Lecithin	.54
			Cholesterin	.85
			Sugar and other organic substances	.23
		Inorganic:	Salts, similar to those of the lymph	.79
				100.00

The physical composition of the lymph bears a close resemblance to that of the blood. Like the latter it consists of plasma and corpuscles. The plasma differs in no essential character from blood plasma: straw-colored and clear; alkaline in reaction, through Na_2CO_3 and Na_2HPO_4; coagulable under the same conditions as those which govern the clotting of blood, and as a result of the same factors—fibrinogen, fibrin ferment, and calcium salts; saltish in taste, because of the presence of 0.6 per cent. sodium chloride; specific gravity lower than blood plasma because of the smaller proportion of salts.

The lymph corpuscles are simply leucocytes. They are formed mostly in the lymph glands, and are put into circulation first in the lymph, and with the lymph enter the blood circulation through the thoracic duct.

4. The Theory of Lymph Formation.—A brief historic review is necessary to give one an idea of the way in which the present theory of lymph formation developed.

Asellius [1] discovered the lacteals (1622) and thought that they carried absorbed food to the liver for elaboration into blood.

Rudbeck [2] discovered the general lymphatics (1653) and observed that lymph clots like blood and has a salt taste.

Bartholin [3] discovered, independently, the general lymphatics, and believed that lymph formed from blood by filtering through the tissues and that it represented water and salts of the plasma.

Pecquet [4] discovered the connection of the lacteals with the thoracic duct and through this with the venous system (1654).

Monro [5] believed that the lacteals filled by sucking digested food-stuffs from the intestinal canal (1757).

Bichat [6] believed that tissue spaces filled from the blood-vascular system through exhalant arteries ("vasa exhalantia"), that the lymphatics filled from the tissue spaces through open mouths and lacteal vessels by "capillary attraction," and that lymph kept moving through "vital activity" of cells and tissues (1812).

Dutrochet [7] discovered *endosmosis*, and many physiologists believed the riddle of absorption and formation of lymph to be finally solved. The importance of osmosis has been generally recognized by physiologists since that time; but the part which it plays has been variously estimated (1827).

Hunter [8] believed with the older writers that the lacteals filled by suction from the alimentary canal, and that the general lymphatics filled by suction from the tissue spaces. As to the filling of the tissue spaces he recognized the possibility of a filtration through the walls of the blood-vessels (1835).

Johannes Müller [9] did not accept the mechanical theory (capillary attraction, etc.); but, observing that the lacteals did not absorb all solutions from intestines without respect to kind, conceived the idea of "selection," and believed that the formation of chyle was due to the "vital activity" of the living cells of the intestinal wall (1838).

We come now to the last half of the nineteenth century. Over two centuries of speculation guided by an occasional observation had passed since the lymphatics were discovered. Speculation had run the gamut of theories—filtration, capillary attraction, osmosis, vital activity. The physiologists of the period of physical, chemical, and microscopic research were to turn on the searchlight of modern science to solve the problem of lymph formation and movement.

Carl Ludwig [10] approached this problem in his characteristic way. He applied here the methods of the physical laboratory, testing through the mercury manometer the blood pressure, the venous pressure, and the lymph pressure, and, in consequence of his observation of high blood pressure and low lymph and venous pressure, maintained that the lymph resulted from filtration of plasma through the capillary walls. In 1861 Ludwig [11] summed up his theory of lymph formation through filtration and diffusion as follows:

"The blood which is contained in the vessels must always tend to equalize its pressure and its chemical constitution with those of the extravascular fluids, which are only separated from it by the porous blood-vessel walls. If, for example, the quantity of blood in the vessels has increased, the mean blood pressure is also increased, and at once a portion of the blood is driven out into the tissues by a mere process of filtration. The same result is brought about when the constitution of the blood is altered by the absorption of food or by increased excretion by the kidneys, blood, or skin, or when the composition of the tissue fluids is altered in consequence of increased metabolic changes taking place in the tissues. In the latter case the changes brought about in the lymph are effected by processes of diffusion."

Ludwig's theory was generally accepted by physiologists for about four decades. Little work was done during that time. The work done by Tomsa,[12] by Emminghaus and Paschutin,[13] and by Rogowicz [14] all led to results in harmony with the *filtration* theory of lymph formation.

Heidenhain [15] experimented upon the lymph flow from the thoracic duct and concluded that his observations were irreconcilable with the filtration theory, and that "we must assume that the cells forming the walls of the capillaries take an active part in lymph formation, *i.e.*, that the lymph must be looked upon as a *secretion* rather than as a transudation."

During the last decade of the century the whole field was carefully re-worked by many skilled observers. A question which had seemed to be settled was again opened by Heidenhain's work, and many new experiments were instituted to determine the parts played by physical and vital forces.

Valuable contributions were made by Cohnstein. Experiments to reproduce the physical relations of the blood and lymph circulations were tried.[16a] A tube of animal membrane, representing the blood-vessels, passed through an outer tube, representing the lymph spaces of tissue. The fluid in these two tubes was subjected to varying pressures with results that led the experimenter to conclude that the pressure within the inner tube (always much greater than that in the outer) was a more important factor than any variations of pressure in the surrounding liquid. On the whole, the author held to the filtration theory rather than to the secretion theory. Cohnstein [16b, c] showed that a considerable but variable time elapses after an intravenous injection of salt or sugar solution before the lymph is affected, and that simultaneous tests of blood and lymph may be misleading.

Researches made by Lazarus-Barlow,[17] by Bainbridge,[18] and by Moussu,[19] all resulted in conclusions favorable to the filtration theory of lymph formation.

In the mean time other experimenters got results which seemed to point to a secretory activity on the part of capillary walls. Hamburger [20] found in a horse under observation that there was an increased flow of lymph from the ductus colli, at the same time that there was decrease of both carotid and jugular blood pressure.

Tscherewkow[21] found no change in the amount of lymph which passed from the thoracic duct after hemorrhage, and concluded therefore that there is difficulty in affirming a direct relation between capillary pressure and lymph formation. Ostowsky[22] made tests of the efferent lymph stream from the testis after intravenous injections of salt, sugar, peptone, etc., and concluded that "lymph flow is practically independent of general blood pressure."

Popoff[23] made experiments on the intravenous injection of dextrose, varying the method of Heidenhain by injecting rapidly (one to two minutes) rather than slowly (thirty minutes), and found that the maximum amount of sugar in the blood was never less than that in the lymph; that the lymph flow from the thoracic duct was increased, but not in proportion to the amount of sugar injected; that the urine is also considerably increased, and that sugar is freely excreted through the urine.

Pugliese[24] investigated the formation of lymph in the fore leg of a dog, and found that venous stasis caused an increased flow of lymph, thus favoring the filtration theory. He found, further, that either active or passive movements of the leg increased the amount of lymph without changing its composition. About this time Asher,[25a, b] associated in a part of his work with Barbèra,[26] made some important contributions to the problem in question, and though he took a middle ground by declaring that "some of the facts discovered can be accounted for upon the physical basis (filtration and osmosis), and some upon the physiological (secretion)," he involved the problem still more by announcing a new factor, viz., *organic activity*. He presented a strong series of facts to show that whenever the activity of an organ is increased, the flow of lymph from that organ is also increased.

Thus during the period of active investigation of the subject of lymph formation a great mass of facts had been established, but the physiological world was still in doubt as to the relative importance of the various possible factors involved in the formation of lymph. The time had come for an analytical mind to take up the subject and bring order out of chaos. This analytical mind was furnished by Dr. E. H. Starling, of London. Starling made an important series of contributions to the literature of this question in 1894 and 1896,[27, 28] and in 1898 he made a masterly review of the whole problem, weighing in a most liberal and impartial manner the various contributions to the solution of the problem of lymph formation.

The early work was subject to criticism in that the experimenters had studied the flow of lymph from the leg and had been obliged to subject the tissues to massage in order to get a flow.

Tigerstedt[30] had first called attention to this difficulty with the early work. Heidenhain recognized the validity of this criticism and devised a new method to avoid it. He studied the flow from the thoracic duct, and assumed that this represented the lymph formation of practically the whole organism. Heidenhain's long investigation was based upon this apparently tenable conclusion, and, as stated above, led to results irreconcilable with the filtration theory.

Starling[29] showed that the flow from the thoracic duct does not represent the general lymph formation. The lymph flow from the anterior limbs, and head and neck, does not enter the thoracic duct, while that of the posterior is so small in amount that it need not be considered; furthermore, the amount which enters from the thorax is so slight that no difference is observed when the cannula is inserted just above the diaphragm instead of near the subclavian vein. It becomes apparent, then, that the flow of lymph from the thoracic duct represents the lymph formation in the abdominal viscera; and these may be further differentiated into two regions: (1) the portal, and (2) the hepatic; or the lacteal and the liver regions.

Starling next demonstrated that the lymph from the liver is most concentrated (*i.e.*, contains the largest proportion of solids), that from the portal region is next in its degree of concentration, while that from the limbs, head, and neck is least concentrated. He later showed that this varying degree of concentration consisted principally of a varying proportion of proteid, and that the variation of proteid depended upon the varying permeability of the capillaries in the three regions; the permeable liver capillaries allowing proteid to filter through so easily that it makes six to eight per cent. of the liver lymph; the less permeable capillaries of the portal region permitting only four to six per cent. to filter through; while the least permeable capillaries of the extremities permit only from two to four per cent of proteid to pass.

After a careful examination of Heidenhain's experiments on the flow of lymph from the thoracic duct, Starling concluded that, "the lymph production in the organs of the abdomen is directly proportional to the capillary pressure in these organs; and not independent of it as was imagined by Heidenhain."

The next step in the review of the controversy was to determine the influence of hydræmic plethora. It was found that this condition may be artificially produced in two ways: first, by injecting intravenously an isotonic solution of sodium chloride (normal saline solution) to the extent of from 300 to 500 c.c.; second, by injecting intravenously a condensed solution of sodium chloride or of dextrose, thus giving to the plasma a high endosmotic attraction for tissue lymph. The blood plasma promptly draws through the capillary wall the tissue lymph, thus draining the tissues and temporarily decreasing lymph flow and increasing intracapillary pressure. The natural reaction to this condition is a much increased filtration of plasma from the over-filled blood system (condition of hydræmic plethora) into the lymph spaces of the tissues, and this in turn is followed by an increased flow of lymph along the lymphatic vessels.

That the increased lymph flow is conditioned upon the hydræmic plethora and not upon the simple presence of the salt or sugar in the blood was demonstrated by Starling through simply withdrawing an amount of blood equal to the aqueous solution injected or to the tissue lymph drawn in by osmosis; the result being an increase of the salt (or sugar) without increasing the volume of blood. This procedure resulted in no increase in the flow of lymph, thus proving that it was the condition of hydræmic plethora, *i.e.*, of increased blood pressure, which caused the increased lymph flow, and not the presence of the increased quantity of salts (or sugar) in the blood.

These soluble, crystalline substances, salt, sugar, potassium chloride, etc., made Heidenhain's second class of lymphagogues. It is apparent that their lymphagogic effect was due to the increased capillary pressure which accompanied their use, and not to any specific stimulation which they exerted upon the secretory activity of the endothelial cells of the capillaries. In harmony with this opinion are the results of Timofejewsky.[31] But the increased blood pressure causes increased filtration; and thus it transpires that the observation which Heidenhain cited to show the untenability of Ludwig's hypothesis only made that hypothesis more secure when rightly interpreted.

Heidenhain's first class of lymphagogues (extracts of leech, mussel, and crayfish) cause a much increased flow of lymph; but Starling showed that they exert this effect through their toxic action upon the endothelial cells of the capillaries, thus making those cells less able to resist the intracapillary pressure, so that, with the latter normal or even decreased, there will be an increased flow of lymph.

Starling has been able to account for many previously unaccountable things and to reconcile the findings of Heidenhain and his associates with the physical theory. It will be remembered that this theory, as formulated by Ludwig in 1861, accounted for lymph formation on the basis of the combined action of filtration and osmosis. No clearer formulation of the present state of our knowledge of this question can be made than that made by Ludwig forty years ago.

5. The Relation of Lymph to Metabolism.—This relation was indicated, in general terms, under the definition of lymph. As stated above, the lymph is the medium through which every active cell gets its food and its oxygen; it is also the medium into which every cell throws out the waste matter resulting from its metabolism. When we say that lymph is formed by filtration from the blood and modified by osmosis with the blood, we cover the ground of the initial formation of lymph; we must, however, not forget that the lymph is being continually modified, during the time when it is within the several tissues and organs, by the metabolism peculiar to the respective tissues and organs. The blood plasma which filters into leg muscle, intestinal mucosa, and liver is essentially the same in each case, differing only in the respective proportions of proteid, conditioned upon the varying permeability of the capillary walls in these three localities. But the metabolism in these three regions is very different—different not only in respect to what the cells take out of the intercellular lymph, but different also in respect to what the cells throw out into this lymph.

The cells of the muscle will take up fat, dextrose, and proteid from the lymph and throw out various midproducts of proteid catabolism.

The cells of the intestinal mucosa will make no important drafts upon the lymph; they will, however, absorb great quantities of fat, associated with sodium carbonate (Setchenow [32]), and, according to Colin [33] and to Asher and Barbèra,[34] considerable quantities of proteid; and this fat and proteid will be poured into the lymph (chyle).

The cells of the liver will absorb from the lymph not only food and oxygen for their sustenance, but also large quantities of material which represents the midproducts of tissue metabolism. The liver is the great central laboratory of the body where urea, uric acid, bilirubin, and biliverdin are made; where dextrose is taken up from the portal system and changed to glycogen in which form it is stored. To accomplish this, great modifications will be made in both the blood and the lymph which traverse the liver. Of the two fluids the lymph suffers the more profound change.

It must not be forgotten that wherever blood and lymph are separated by a capillary wall osmotic action proceeds, and there will be a modification of both fluids with a tendency toward equalization. The circulation through the liver not being a rapid one, the diffusion of substances between blood and lymph will be considerable. Urea is thrown out into the lymph by the liver cells, and a small part is diffused into the blood. The rest, according to Wurtz,[35] amounting to about 0.016 per cent. of the lymph, makes its way along the thoracic duct, where it is all poured into the venous system and carried presently to the kidneys for excretion.

The lymph contains various substances whose presence and whose relation to metabolism are not understood. There are glycogen and a diastasic ferment,[36] and there is rennet,[37] besides various other substances in traces.[38, 39]

Ransom [40] found that when the toxin of tetanus was injected into the blood not more than one-third of it ever found its way into the lymph. Similarly when tetanous antitoxin is injected it is retained to the amount of two-thirds in the blood.

6. The Movement of Lymph.—Frequent mention has been made of the flow of the lymph. Let us now consider what it is that causes the lymph to flow.

Like the veins the lymphatics are thin-walled and provided with valves; like the veins the lymphatics are filled from the capillaries by force from the heart, the difference being that the heart forces the blood in a million of capillary streams into the veins, while it forces the plasma of the blood in many hundred million streams through the pores of the capillary wall into the lymphatics.

The initial and principal force which causes the lymph to flow is the *vis a tergo* from the heart, which pushes it on farther and farther from the tissue among whose cells it escaped from the capillary. As it moves forward it is gathered into the lymph radicles; these in turn are tributary to the smaller lymphatics. Once the lymph reaches a lymphatic there is no retreat because the valves block all backward flow.

The heart force alone would be sufficient to cause the lymph to flow throughout its system of vessels and back to the subclavian vein. There are two forces, however, which are of great importance in assisting this flow. These forces are the negative pressure of the thorax, and the positive pressure exerted upon the blood and lymph vessels by contracting muscles.

Every one is familiar with the influence of negative intrathoracic pressure upon the flow of blood in the veins. Its influence upon the flow of lymph is as important as that upon blood. These fluids are actually pumped into the thorax as water is lifted by a suction pump. Furthermore, the downward movement of the diaphragm makes positive pressure in the abdominal cavity at the same time that it makes negative pressure in the thorax. Thus there is exerted on the lymph in the abdomen both a *vis a tergo* and a *vis a fronte*.

Besides this force exerted by the respiratory movements there is a pressure upon the sides of veins, of lymphatics, and of arteries within contracting muscles. The arteries can by their thicker walls resist this lateral pressure, but the contents of the veins and lymphatics are forced forward—backward movement being made impossible through the closure of the valves.

Hewson [41] believed that lymph was kept moving in the lymphatics by peristaltic movements of the walls of the lymph vessels; but there is no reason to believe that any such movement takes place in any of the higher animals.

The rate of lymph filtration and flow has been investigated by Tschirwinsky.[42] By injecting salicylate of sodium into the blood or lymph stream the time required for it to appear at the upper end of the thoracic duct could be accurately determined. With this method he was able to show: (1) that it required from four to seven minutes to pass from the descending aorta to the thoracic duct; (2) that it required from two minutes ten seconds to three minutes to pass from the femoral artery to the pedal lymphatic; (3) that it required one minute twenty seconds to flow from the pedal lymphatic to the thoracic duct; (4) that it required from thirty seconds to one minute to filter through the tissues.

The flow of lymph seems to be without direct nervous control, though Spallitta and Consiglio.[43] by inducing high pressure in the thoracic duct, observed an increase of blood pressure, and slower, stronger heart beat, which suggested a reflex response to change in the lymph pressure. This points to the probable presence of afferent nerves from the larger lymphatics to the cardiac centres in the medulla. *Winfield S. Hall.*

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LYMPHANGIECTASIS.—It might with propriety be expected, from the analogous process in the blood-vessels, that dilatation distal to the obstruction of the lymph vessels would occur with equal regularity. Such a sequence is a common event with interference of the venous current. In the lymph vessels dilatation rarely takes place from simple hindrance to the circulation, and it is quite universally agreed that the anastomoses in this set of vessels are so abundant that a collateral circulation is readily and speedily established after blocking of one of the branches.

Interferences of the circulation in the larger branches, however, may result in disturbances that attract attention; they may be of a transitory nature like the œdema of the arm that surgeons become familiar with, following dissection and removal of the lymph glands of the axilla in cases of carcinoma of the mammary gland; or the symptoms may be of a persistent and serious character, as it is, for example, in the chylous ascites that occurs from obstruction of the thoracic duct. The adult forms of filaria are said to lodge in the larger lymph and chyle passages and cause, among other symptoms, the appearance of chyle in the urine.

Dilatation of the finer branches of the chyle-carrying vessels is readily detected in the lining of the small intestine, during the gross examination, by the fine tracery of whitish or silver-like anastomosing lines and small flat retention cysts with rounded margins, that yield a milky fluid when broken or sectioned; all are very superficially located in the mucosa and are not removable by a stream of running water.

To consider dilatation of the lymph vessels apart from its chief and most important result, elephantiasis, leads naturally to recording unusual and rare conditions of much less importance. Not all accidents, operations, and pathological conditions that interfere with the circulation in the lymph vessels are followed by elephantiasis; in fact, such a sequel is uncommon. Yet when it does occur, it is quite generally ascribed to obstruction of the lymph channels. On the other hand, the clinical history of many cases of elephantiasis denotes an infection that is often unconnected with operations or other mechanical factors which would interfere with the return flow of the lymph. In these cases repeated attacks characterized by chills that are followed by fever, with swelling, itching, and redness of the growing part, have led to the employment of such terms as "recurrent erysipelatous lymphangitis," "erysipèle à répétition," etc.

It does not seem out of place to question the occurrence of elephantiasis without a primary infection, as well as the rôle in its etiology played by obstruction of the lymph channels; at least the extent to which these factors operate, singly or together, is worthy of consideration and investigation. It is not unlikely that the obstruction is secondary to the infection in many cases and that the recurring cellulitis is to a large degree responsible for the hyperplasia of tissue constituting the main element in these singular cases. In other instances the infection occurs following operations which interrupt the continuity of the lymph channels.

Hamann has observed cases of elephantiasis following extirpation of the inguinal lymph glands. One case described in detail occurred in a woman from whom the glands were removed during the dissection of the sac in a femoral hernia. Six weeks after the operation and three after her recovery, chills and fever accompanied by swelling and redness of the labium majus on the same side occurred, and during the following four months seven or eight similar attacks were experienced. During each attack an increasing brawny induration of the labium took place. The diagnosis was made of lymphangitis accompanied by lymphatic œdema due to interference with the flow of lymph, produced by removal of the fat and lymph glands and the succeeding cicatricial contraction. Hamann was at a loss to account for the absence of suppuration. There is small room for doubt that in cases of this kind infection, added to the interruption of the lymph current, brings about the hyperplasia of the subcutaneous tissues, constituting elephantiasis. Other operators have had similar undesirable consequences following removal of the lymph glands and have abandoned extirpation for incision and curettage.

Other cases of elephantiasis with recurring symptoms denoting infection, with each of which there is a progressive enlargement of the affected region not unlike erysipelas, are entirely unassociated with operative procedures. If obstruction to the lymph currents are present in such cases, it may be that they occur early in the course of the lymphangitis. In some of these cases papular eruptions accompanied by an intense pruritus are noticed early.

Whether a cause or a result, lymphangiectasis is a constant feature of true elephantiasis. The enlarged lymph vessels are noticeable in all regions from just below the epithelium—on microscopic examination—to deep within the hyperplastic corium and subcutaneous tissues; they contain no red blood corpuscles, but are found adjacent to the arteries and veins. The arteries are frequently the seat of an endarteritis, obliterative in character, and around all the vessels collections of the so-called round cells—many of which are plasma cells—occur. Dilated lymph vessels are not especially numerous and the structure of the tissue is usually dense fibrous tissue.

There is a very close connection between lymphangiectasis and certain forms of lymphangioma. The definition given by Senn for a lymphangioma is "a tumor composed of lymphatic vessels produced from a matrix of angioblasts." He construes the vessels as newly formed. The proliferation of lymph vessels as a result of inflammation or of even mechanical obstruction of the current must be looked upon as a process of regeneration. The lymphangiomata of the neck, which are usually cystic and congenital, occur in the region of the large lymph channels and are believed to arise from congenital anomalies in them. The lymph collects in them because they are disconnected from the proximal vessels and lymphangiectasis may be said to be present. If, however, proliferative processes are found, as, for example, were present in a case described by Tilger, the lesions are by many authors counted as tumors. It might be possible to consider these proliferative processes, consisting usually of a multiplication of the endothelium, as regenerative in nature, but abortive.

In Wegner's classification of the lymphangiomata, the tumors of one group are said to have their origin in obliteration of efferent lymph vessels through compression, inflammation, or congenital anomalies. Such forms of

lymphangiectasis, if grouped with tumors—lymphangioma—must be clearly separated from the forms in which the essential process is the production of new lymph vessels. The cystic dilatations of lymph channels in the neck, that are virtual retention cysts resulting from maldevelopment in these channels, may form chains of sacs, large and small, lying along the internal jugular vein and other great vessels, and sometimes extending from the mediastinum to the cavity of the mouth. Their dissection is laborious.

Similar retention cysts or localized dilatations of the lymph vessels, and also described as lymphangioma, have been found in the mesentery. Weichselbaum has reported one under the name of chylangioma from its milky or chylous content. In an incarcerated omental hernia at the femoral opening von Hopffgarten found in the hernial sac a mass of tissue, 4.75 by 3.5 cm., in which there were numerous small subserous cysts, varying in size from a millet seed to a cherry.

His conclusion, after a careful microscopic examination, was that the cysts had their origin in lymph vessels that were dilated from obstruction. He points out the analogy between his case and the lymphangiomata which Wegner claims arise from granulation tissue by secondary changes—in other words, which take their origin from an inflammatory process.

That the lymph channels do proliferate in the ordinary processes incidental to healing seems evident from the descriptions of Talke, who in a recent article has described new lymph vessels in the scar tissue produced as a part of the adhesions about the ascending colon in a case of perityphlitis, and in analogous pleural lesions.

E. R. Le Count.

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LYMPHANGIOMA.—See *Angioma* and *Hygroma*.

LYMPHANGIOMA CIRCUMSCRIPTUM.—This is an affection characterized by the presence of small vesicles, often arranged in clusters, irregularly distributed, and deeply seated in the skin, and is of rare occurrence. The clusters may have a circular form, or they may be arranged in bands, which sometimes have the appearance of being seated over the course of nerve tracts, or of the large lymphatics. The affection has been found most frequently on the upper extremities, and especially in the scapular and axillary regions, and in a large portion of published cases it has appeared on the left side of the body.

These vesicles vary in size from a pin's head to a small pea, and the epidermis over them is often affected by a warty change, so that some of them may on first sight simulate warts, and occasionally there have been present long warty projections. An interesting feature is the presence usually of telangiectases, or large dilatations of the blood-vessels in the area occupied by the vesicles, as well as in the roof of the vesicles themselves. When the vesicles are ruptured they exude a clear, colorless fluid.

The affection is frequently accompanied by recurrent attacks of an inflammation of the affected area that resembles in type erysipelas, and it has sometimes been classed with the latter disease. These attacks are accompanied usually by some constitutional disturbance and considerable pain. In some instances they have preceded a fresh outbreak of vesicles, in others they have had no perceptible effect on the eruption. They differ from true erysipelas in not spreading to other parts of the body, and have been compared by Besnier to the "erysipelas" that occurs in elephantiasis.

The affection is very slow in its course, appearing either at birth or in infancy or childhood, and often remaining stationary for many years. There is often an hypertrophy of the fibrous tissue in and about the affected area, so that a condition of elephantiasis may be produced. This is seen also in other varieties of lymph-

FIG. 3262.—Congenital Lymphangioma Circumscriptum. (Case of Dr. Isadore Dyer, of New Orleans, La.)

angioma. Thick, firmly adherent crusts are often produced by the bursting of the lesions, and, being deeply embedded, they may persist for a long period.

ETIOLOGY.—The disease usually begins in infancy or childhood, in one or two cases only in adult life. It is probable that it is always of congenital origin. Injury and irritation have been thought to affect the process, and in several instances excision has led only to an increase in the number of lesions.

ANATOMY.—The writer's examination of a lesion removed from the arm, which was not associated with any telangiectases, nor with fibrous or warty changes, showed numerous cysts in the upper part of the corium and approaching very near to the epidermis without implicating it. The cysts were filled with fibrin and a few leucocytes, and were often divided into subdivisions by septa formed of the unaltered corium. These cavities possessed an endothelial lining, and there could be no doubt that they represented newly formed or dilated lymph vessels or channels, as they communicated with the lymph channels below. There was a certain amount of leucocytic infiltration about the cysts. A few enlarged blood-vessels were seen.

The implication of the blood-vessels varies in different cases, and in different lesions in the same case. In some instances it has been found that the corium contains numerous dilated blood-vessels, together with the enlarged lymphatics, and that the telangiectases and vascular dots that have been referred to are caused by the presence of dilated capillary blood-vessels between the upper wall of the cysts and the epidermis.

DIAGNOSIS.—This may be made from the appearance

of the affection at birth or in early life, by the groups of thick-walled vesicles, often accompanied by telangiectasis and warty surface changes, by the discharge of lymph, when they are incised, and by the slow course. On superficial inspection the affection may resemble most a group of warts.

Prognosis.—The lesions usually increase slowly until they have attained a certain degree of development, when they remain nearly stationary. In one recorded case there has been spontaneous involution. After operative interference, as in all forms of lymphangiomata, the lesions are very likely to reappear.

Treatment.—Excision and caustics have been tried, but recurrence after the operation is not uncommon. Electrolysis has been thought by some to offer the most hope of success, but in this case also recurrences have been recorded. Each vesicle is to be transfixed by a needle attached to the negative pole of a galvanic battery, eight or ten cells being employed. The poor results of treatment probably are due to the presence of deep-seated anastomoses. *John T. Bowen.*

LYMPHANGIOSARCOMA. See *Sarcoma*.

LYMPHANGITIS.—All the tissue elements may be regarded as being bathed in lymph, which appears first in innumerable, minute, irregular gaps in the tissues, which gaps communicate in various ways with each other, and with minute lymphatic vessels, which latter, when traced onward from their beginnings, presently assume a structure comparable to that of narrow veins with very delicate walls and extremely numerous valves. These valves open away from the gaps of the tissues, as the valves of the veins open away from the capillaries. The lymphatic vessels emerging from the network of gaps unite to form somewhat larger ones, which pass either to a neighboring lymphatic gland or to join some larger lymphatic trunk. The lymphatics are arranged into a superficial and a deep set. The superficial lymphatics on the surface of the body are placed immediately beneath the integument, accompanying the superficial veins; they join the deep lymphatics in certain situations by perforating the deep fascia. The deep lymphatics, fewer in number and larger than the superficial, accompany the deep blood-vessels. Finally, the entire system ends in numerous vessels which open into two main trunks of very unequal importance—the thoracic duct and the right lymphatic duct. Lymphatics are found in nearly every texture and every organ of the body which contains blood-vessels. Interposed at numerous points in the course of the lymphatic vessels are the lymphatic nodes, which are small, solid, glandular bodies through which the lymphatic vessels pass. Lymph is the exudate of some of the liquid constituents of the blood as it circulates through the capillary blood-vessels into the tissue gaps or spaces, and carries nutriment to the tissues. It then receives from the tissues the products of their activity, and is collected from the lymph spaces into the lymph channels, whence it is carried to the lymph nodes, which act as filters for the lymph, besides adding to the lymph the lymphocytes, which act as scavengers (phagocytes) in the lymph and blood.

Reticular lymphangitis is applied to inflammation of circumscribed areas of lymphatic radicles, tubular lymphangitis to that of the larger continuous lymphatic trunks. Both forms often coexist. Either may be acute or chronic. Since we now know that all inflammation of lymph vessels is of microbic origin, we may drop the terms "idiopathic" and "traumatic" as being no longer descriptive. The lymphatics are so widely distributed that they must be severed or torn in every cut or bruise to a greater or less extent; but, as a rule, they collapse at once and give no trouble. From their open mouths, during the first hours following the receipt of a wound, comes much of the serous flow, to dispose of which drainage is necessary. This outward flow of the lymph, together with its coagulation and the collapse of the lymph vessels themselves, prevents the absorption into the organism, in most instances, of septic material. While lymphangitis is, generally speaking, the consequence of a wound, yet this is not an invariable rule, since infection has been known to penetrate through the unbroken skin of the hand, as seen in sepsis following immersion of the unwounded hands in the fluids of a cadaver at an autopsy, and also through mucous membranes in which there is no abrasion or scratch to be found, especially in the case of the throat, uterus, etc. The absorption of infective material is undoubtedly greatly facilitated by friction, pressure, the removal of the outer corneous layer, or the confining of a discharge under tension. Recent wounds are much more likely to be attacked than granulating ones, because granulations themselves, so long as they are uninjured, do not absorb, the current setting in the opposite direction toward the surface. Whatever the irritant may be, it probably does not cause inflammation of the wall of the vessel unless it is arrested; if this does not take place, it is hurried on to the neighboring lymphatic glands, and sets up inflammation there. Illustration of this is seen in cases in which surgeons have received the tiniest needle prick, so slight as to leave no mark, in which the first intimation of sepsis is found in inflamed lymph nodes in the neighborhood. The heat of the sun and the Roentgen rays produce an inflammation of the skin in which the lymphatics share to a certain extent. Lymphangitis is incidental to the course of specific diseases, such as scarlet fever, measles, diphtheria, tuberculosis, syphilis, and gonorrhœa; in these, however, the inflammation of the lymphatic nodes is the more prominent feature. A typical lymphangitis is seen in erysipelas (which see). It may also result from the bites of insects and venomous reptiles. It is a constant lesion in bubonic plague.

Pathology.—The changes are best seen in the larger trunks. Their endothelial cells swell, lose their distinctness of outline, and to a variable extent become detached. The walls of the lymph vessels and the delicate surrounding cellular tissue become more or less densely infiltrated with pus cells, fibrin, and serum. The lumen of the vessel, the interstices in its walls, and the cellular sheath are filled with a coagulating exudation. The stream of lymph through the vessel ceases because of the thrombus. The blood-vessels surrounding the inflamed area dilate, and the blood circulates more rapidly and in greater quantity. The future course, whether it is to be either resolution, organization, or suppuration, depends upon the cause. If the irritant be slight and transient, resolution may begin at once. The thrombus liquefies within the lumen, and the exudate within and without the walls is absorbed. The endothelium is regenerated and the circulation is re-established. Organization is likely to occur if the irritant action is chronic and persistent, as in syphilis. The lumen becomes occluded through transformation of the thrombus into connective tissue, and the coats of the vessels and the cellular tissues in which they lie become hard, dense, and sclerosed, likewise from organization of the exudate into connective tissue, and some degree of permanent thickening results in the tissues. Suppuration takes place when virulent micro-organisms are the exciting cause, producing coagulation-necrosis of the thrombus and exudate, and death of the vessel wall and surrounding tissues, resulting in cellulitis, or abscess, which may be circumscribed, or diffuse and spreading. The related neighboring lymph nodes are usually implicated also. The results of the extension of infection along the lymphatic channels are seen in some cases of suppurative appendicitis, where we may find inflamed mesenteric glands, isolated abscesses about the liver, empyema, etc.

Symptoms.—In the reticular form the inflammation shows itself in red, tender, œdematous, swollen patches, which may succeed each other up the limb, one fading as a neighboring area blooms out. The inflammation extends from the periphery. Pain is always present and varies, like the other symptoms, with the severity and extent of the process; it is increased by movement, and is accompanied by a feeling of tension in the part. Ordinary erysipelas presents a typical form of reticular

lymphangitis in which the inflammation is produced by the invasion of the lymphatic channels by the streptococcus of erysipelas. If the inflammation is extensive there may be a considerable lymphatic œdema and the circumference of a limb may be much increased. Some cellulitis accompanies all lymphangitis, and some lymphangitis, on the other hand, attends all cellulitis. Which element preponderates is very often a matter of uncertainty, but the question is not an important one, because both require the same treatment.

The tubular variety shows itself most plainly when the superficial vessels are involved. These latter appear in the skin as wavy red lines travelling toward the neighboring lymphatic glands. They are very tender to the touch, slightly raised from the surface, with a cord-like beaded feel, due to the infiltration and plastic thrombosis in and around them. Sometimes they are quite narrow; sometimes, when the poison is very active, an inch or more in breadth, from extension of the inflammation to the surrounding cellular tissues. At the same time the glands are swollen and tender, and, if the affection is extensive, the limb below may be œdematous. Here and there the red lines disappear, where the superficial lymphatics empty themselves into the deeper set, or swell out and become broader opposite plexuses and valves. In cases of virulent infection the inflammation may result in the formation of small abscesses at intervals along the course of the vessels before the glands are reached.

When the deeper vessels are affected, the diagnosis may not be easy if no superficial inflammation be present. Usually, however, faintly outlined patches of redness are visible here and there upon the skin, where the superficial plexuses communicate with the deep ones. In any case deep pressure along the course of the affected vessels is painful, but otherwise most of the usual signs are wanting. Diagnosis between it and ordinary cellulitis is difficult. In both varieties the glands are apt to be swollen and tender.

The constitutional symptoms will vary according to the extent of the local inflammation, the severity of the cause, and the general health and resisting power of the patient. Simple lymphangitis is accompanied by a varying degree of fever, with the usual results thereof—malaise, thirst, headache, anorexia, etc. When suppuration sets in, the general symptoms become much aggravated, pain is severe and prostration extreme, and high fever with possibly chills and sweating makes itself evident. In severe cases septicæmia may develop.

Prognosis.—Simple lymphangitis is rarely serious and runs its course in from a few days to several weeks; the general health and robustness of the patient have a marked influence, recovery being slow in the subjects of alcoholism, chronic gout, diabetes, and renal disease, and in those debilitated by poor living and overwork. When suppuration supervenes (leading to a cellulitis) or when some virulent septic poison is the cause of the trouble, the illness may assume a grave character, viz., that of septicæmia. If the vessels which run in groups are extensively destroyed, a condition of solid œdema is likely to persist which may leave the limb more or less crippled.

Diagnosis.—Phlebitis is closely related to lymphangitis in its symptoms, but a thrombosed vein forms a deeper-seated, coarser cord than does a similarly affected lymph vessel, the cutaneous redness is not so vivid, the pain is less acute, the general fever is not so intense, and the tendency to glandular involvement is much less. Inflammation of the deep lymphatics may at times be differentiated from ordinary cellulitis by an earlier involvement (in the case of the former of these two inflammations) of the neighboring lymphatic glands, by the presence of lymphatic œdema, and by the appearance of patches of superficial reticular lymphangitis at points of anastomosis with deeper trunks.

Treatment.—The first indication is to remove the cause, if that can be detected. All possible sources of infection should be sought for and appropriately treated. Pustules and abscesses should be opened and drained, unhealthy wounds are to be cleaned thoroughly and opened further if drainage is not sufficiently free. These avenues of infection should be encased in compresses which are kept wet with some antiseptic solution. The part should be put at rest, and the limb elevated to diminish the amount of blood entering it, as well as to facilitate the return of the lymph. Tension within the area of lymphangitis, if very great, should be relieved by incision and drainage, without waiting for suppuration to take place. The whole affected area should be kept covered with compresses continually wet with some soothing, antiseptic solution, such as aluminum acetate, Thiersch's solution, creolin (one-half per cent.), bichloride (1 in 2,000), or a solution of lead and opium. These wet dressings should extend above and include the swollen lymphatic glands. Hot fomentations in some cases may be more grateful than the cooler solutions. As soon as pus forms or is suspected, the abscess should be freely incised, evacuated, and drained. In severe cases in which the process threatens to spread and is difficult to control, a very effectual means of combating this is found in the continuous immersion of the limb in an iced solution such as any one of those mentioned above.

Constitutional treatment consists in supporting and eliminating measures. The diet should be liberal and solid food should not be withheld unless a high degree of fever causes it to disagree. The bowels should be kept freely open. Quinine, and later iron in addition, are the most efficient medicines. Stimulants will be needed only in severe cases and should then be given in large doses (one to two ounces of whiskey every two hours). It seems remarkable (much discussion to the contrary notwithstanding) how favorably a free exhibition of alcohol in severe septic infections will affect the constitutional symptoms, as shown by a dry, brown tongue becoming cleaner and moister, by improvement in the appetite and in the cerebral symptoms, by strengthening and slowing of the heart, and by a diminution in the degree of the prostration. Persistent œdema and stiffness in muscles and tendons, after subsidence of the inflammation and healing of the wounds, are to be overcome by bandaging, hydrotherapy, electricity, and massage. It may be necessary to give analgesics and hypnotics, such as the bromides, codeine, and trional, during the acute stage. Opium should be used only as a last resort.

Chronic Lymphangitis.—This is seen in the course of certain diseases, such as elephantiasis (which see), bubonic plague, tuberculosis, syphilis, etc. Tuberculous lymphangitis occurs both in large and in small lymph vessels in whose walls miliary tubercles and diffuse tubercle tissue may grow, producing partial or complete obstruction. This may occur independently, but it is most frequently seen in connection with tuberculous inflammation of adjacent structures, particularly the lymph nodes. In the vicinity of tuberculous ulcers in the intestines, the subserous lymph vessels, which pass from the ulcers, are often distended with the products of tuberculous inflammation, which makes them look like dense white knobbed cords. Syphilitic inflammation of the lymph vessels not infrequently occurs in the vicinity of syphilitic ulcers in the primary stage. In later stages there may be thickening of the walls of the vessels and the development of gummy tumors in and about them.

Clarence Arthur McWilliams.

LYMPHATIC SYSTEM.—(Synonyms: Absorbent system; Latin, *Systema lymphaticum;* French, *Système lymphatique;* Italian, *Sistema linfatico;* German, *Lymphsystem oder Saugadersystem.*) The lymphatic or lymph vascular system consists of the vessels and spaces containing lymph or chyle (colorless or white blood), and of the lymphatic or conglobate glands situated in the course of the vessels, and through which the lymph must percolate in somewhat the same manner as water passes through a sponge. This system is an appendage of the blood-vascular system, its two terminal trunks, the thoracic duct and the right common lymphatic trunk, ending in the great veins at the base of the neck.

A tolerably correct pictorial idea of the entire vascular

system may be formed by considering the blood-vascular part as made up of a great tree, the heart forming a short trunk and the arteries, veins, and capillaries, the branches; but there is present the untree-like character of the direct union of the terminal twigs of the arteries and veins, that is, the venous and arterial capillaries are continuous. The lymphatic system may then be represented by two vines of unequal size, but which together follow all the blood-vessels to their ultimate ramifications, and in many places even send minute twigs beyond them. The analogy with a vine is further borne out by the lymphatic vessels, as they remain of a more uniform diameter than the blood-vessels; and, finally, the terminal twigs, like those of a real vine, end freely or blindly, often in slight expansions like leaves, thus forming a marked contrast with the terminal twigs of arteries and veins, which cannot be properly said to terminate at all. In a word, the blood-vascular system forms a complete circle or circuit in itself, while the lymph-vascular system joins the blood-vascular system at its central or trunk end, but ends blindly at the periphery.

HISTORICAL.—It is not to be wondered at that the lymphatic system should not have been discovered and investigated before the circulation of the blood and the general relations of the blood-vascular system had been investigated and understood; and yet, from the prominence of the lymphatic glands, they were seen by Hippocrates; but, having no notion of their true relations, he classed them with the other glandular structures of the body; so, too, there is strong reason for believing that the lacteals were seen in animals by the two famous Alexandrian physicians, Erasistratus and Herophilus; but their significance was not comprehended. About the middle of the sixteenth century (1564), Eustachius found the thoracic duct in the horse, and traced it, both to its beginning in the abdomen, where he became bewildered, and to its termination in the great veins in the neck. He did not profess to understand the significance of this vessel, but named it, from its color and position, *vena alba thoracis*.

It was not until 1622, when Asellius saw the lacteals in a dog, that the real significance of these vessels was appreciated. The whole scientific world was about this time aroused by the epoch-making discussions and discoveries of Harvey on the circulation of the blood, and everything like a vessel was scrutinized with inquiring eyes. The story of Asellius in connection with the discovery and comprehension of the significance of the lacteals will never lose its interest as long as the human mind is striving to comprehend the universe, either in its details or in the *ensemble*. Having opened the abdomen of a living dog, to show to some friends the arrangement of the nerves and the working of the diaphragm, Asellius saw in the mesentery some white cords in addition to the nerves and vessels with which he was familiar, and upon cutting one of them and seeing a white liquid exude, he immediately recognized that they were a new kind of vessel. Most fortunately for him and for science, the dog, killed on the following day to find out still more about these curious white veins, showed none of them. Fortunately, because it led Asellius to consider the conditions under which they appeared in the first dog, and wherein the conditions differed in the second. With the sure comprehension of a scientific mind, he saw that the only essential difference lay in the presence of partly digested food in the first case, and in the absence of food in the second. When this condition was realized in a third dog, the lacteal vessels reappeared, and the relation between the products of digestion and these vessels was fully established for the dog.

Not content with the experiments on the dog, Asellius examined many other animals, showing in every case that there was a constant relation between digestion and the presence of the white fluid in the lacteal vessels. Owing to the powerful influence of the prevailing opinion that all matter must first go to the liver to be assimilated, Asellius supposed that the newly found lacteals extended to the liver. It is difficult to comprehend how a mere hypothesis could blind the eyes of so skilled an anatomist, but so it was, and the belief that the lacteals passed to the liver continued to prevail for nearly twenty-five years.

About 1650, the great facts concerning the lymphatic system, as they are understood at the present day, were discovered by four men in different quarters of Europe. In France, Pecquet showed that the *venæ aquosæ hepatis*, or lymphatic vessels connected with the liver, were not the continuation of the lacteals to the liver, but were vessels extending either to the lacteals, or with them into a common reservoir into which both opened, and that the reservoir was continued as a somewhat smaller vessel (the thoracic duct) through the thorax, to terminate in the great veins in the neck. The same facts were observed by Rudbeck, in Sweden, at about the same time, and completely overthrew the notion that all absorbed food must first pass to the liver for assimilation before entering the blood; for here was *apparently* the only path of the absorbed food, and it terminated directly in the great veins on their way to the heart.

At about this date, Bartholin in Denmark, Jolive in England, and Rudbeck in Sweden, discovered the general lymphatics of the body. They also showed that these lymphatics (*vasa lymphatica* of Bartholin, *vasa aquosa* of Rudbeck), or serous vessels, either united with the lacteals in the *chylocyst* or joined the thoracic duct, and consequently the lymph and chyle or lacteal fluid unite, and together flow into the great veins. In other words, they showed that the lacteals form only a special part of a great system distributed throughout the entire body. It may be said, in passing, that when the facts concerning these new vessels were presented to Harvey, he did not welcome the newly acquired knowledge. Doubtless the weight of years had quenched the enthusiasm of investigation, and he may have been troubled lest these newly discovered vessels might in some way prove a stumbling-block to his simple and easily comprehended explanation of the blood-vascular system.

Not much was added to the knowledge of the lymphatic system for nearly one hundred years after the main facts were established, and naturally, in those early times, with both undeveloped methods and superstition as impediments, knowledge was only general and obtained principally by investigating the lower animals. And yet, in 1628, a criminal was properly fed before execution, and the lacteals demonstrated in the mesentery after death, thus showing conclusively that the absorbed food in man takes the same course as in animals.

Between 1760 and 1787 there was a renewed activity in investigating the lymphatic system. In England the Hunters, Hewson, and Cruikshank, not only investigated the human lymphatics, but pushed their investigations to all forms of vertebrates, and they were found abundantly in all forms. The Munros, in Scotland, were also very active. In Italy the great anatomist, Mascagni, was preparing his magnificent work on the human lymphatics, a work which remains a standard to the present day; and reduced copies of his splendid folio plates are still to be found in every extensive account of this system.

As in all departments of human activity, the crowning discoveries in the lymphatic system are due to the work of an almost untold number of men; and yet a few present the principal and salient features so unencumbered with useless, distracting, or foreign details that they are, for the majority of minds, the true discoverers. They make the special knowledge a part of the knowledge of the race. So in the above historical sketch many names have been omitted, and undue prominence may have been given to others; barring these defects, it is hoped that it represents fairly well the progress from vague and uncertain to certain knowledge of this system.

Since the work named above, something noteworthy has appeared almost every decade, but it has been usually toward the elucidation of special details of function, origin, distribution, or structure, rather than an investigation of the whole field. The work of Sappey [1] forms an

exception to this general statement. His investigations have extended over more than forty years, and with a rare skill and all the refinement of modern anatomy, he has not only done much on the general subject both in human and comparative anatomy, but some of the difficult points have been elucidated by him. His atlas is probably, without qualification, the most important monograph that has appeared since Mascagni's.[13]

General Structure in Man and Animals.—Considered as a whole, the lymphatic system consists of minute and larger spaces, of definitely walled capillaries and larger trunks. Lymphoid or adenoid tissue seems also to be an integral part, and in man and the higher forms this adenoid tissue is, in part, aggregated into special masses, the lymphatic glands or nodes, situated in the course of the vessels and forming a sort of sponge-work through which the lymph must percolate on its course to join the blood-vessels.

Like the blood-vessels, the lymphatics may be divided into groups according to their position, as *ectal*—subcutaneous, subserous, or superficial, and *ental*,—subaponeurotic, submucous, or deep, and also as *visceral*—those belonging to the heart, lungs, urinary and generative organs, and the alimentary canal. Part of these, *i.e.*, those from the small intestine, are called lacteals or chyle vessels. All of the larger vessels possess more numerous valves than do the veins.

In distribution, the lymphatics follow mostly the course of the blood-vessels, but this does not apply to the subcutaneous lymphatics, as will be seen by comparing Figs. 3267, 3268, and 3269, with figures showing subcutaneous veins. Furthermore, in many situations lymph vessels, or lymph canals and spaces, extend beyond the blood-vessels and more intimately envelop the tissue elements.

In general, however, it may be stated that the ectal or superficial lymphatic trunks follow the veins, and the deep or ental lymphatic trunks follow the arteries. This anatomical relation was shown in 1836 by Breschet for the adult, and in 1902 by Dr. Florence Sabine[10] for the embryo.

The lymphatic capillary network, although agreeing in general appearance with a blood capillary network, is composed of larger vessels and its mesh is coarser. With the larger vessels the anastomoses are more frequent, but differ in character from the anastomoses of blood-vessels inasmuch as the parallel vessels divide equally or unequally, and unite at a very acute angle, making a long, narrow-meshed network (Fig. 3268); and nowhere is found such great disparity in the size of the vessels as is found with the great arterial and venous trunks. Even the terminal lymphatic trunks are minute as compared with the veins into which they empty. The entire lymphatic system is supposed to have a capacity one-half as great as the arteries, and perhaps more, but no very close approximation can be made on account of the structural peculiarities of the lymphatics, and the immense number of valves. In man and the higher forms, all lymph traverses one or more lymphatic glands before joining the common lymphatic trunks. The exceptions to this rule which have been reported from time to time have not been verified.

In the higher mammals the general arrangement and distribution of the lymphatics is as in man. So far as has been investigated, however, the lymphatic vessels are fewer in number; this is markedly the case with the cutaneous and subcutaneous vessels. The lymphatic glands, although abundant in the horse and ox, are less numerous in most other forms. Groups of glands in man are often represented by a single one or are wholly absent. Although this is the case, a vessel never joins the main trunk without first traversing one or more glands (Figs. 2281, 3284, and 3286). In the lowest mammals there is a strong tendency to symmetry in the lymphatic system, the right and left terminal trunks being more nearly equal in size, and in area from which the vessels come. This tendency is also marked in the horse, and especially so in the rabbit; it is frequently observed in the cat, and occasionally in man. The crossing of considerable trunks from one side to the other is more marked in the lower mammals than in the higher, but even in man considerable trunks not infrequently cross from one side to the other (Figs. 3264, also 3281, 3286); and in all the forms there is the closest possible relation between the two sides through the lymphatic plexuses, that is, networks formed by groups of lymphatic glands and their connecting lymphatic vessels. While it is not uncommon to speak of a network of lymphatic vessels as a plexus, the term is coming to be restricted rather to a lymphatic network in which the glands form the nodal points of the mesh (see Fig. 3263).

Of the animals below the mammalia, the birds possess few lymphatic glands, and these are mostly restricted to the neck. A cutaneous and subcutaneous lymph network has not been demonstrated in the birds. Those that have been shown, it is supposed, correspond with the ental and visceral lymphatics of mammals. The two trunks opening into the veins of the neck are symmetrical, that is, equal right and left trunks. There are also two openings for the lymphatics in the pelvic veins, and lymph hearts are found in this region, but they have muscular walls in only few adult forms (ostrich, cassowary, stork, and sea-gull), although they are contractile in the embryos of birds so far as investigated. Contractile lymph hearts are never present in man and the other mammals (but see below under Development). In addition to the birds mentioned, they are found in reptiles, amphibia, and some fishes. They are mostly situated in the pelvic region, and possess striated muscle which is paralyzed by curare like the skeletal muscles (Kölliker and Ranvier). In the tailless amphibia (Ranidæ) there is a pair of lymph hearts on the thoracic ducts as well as in the pelvic region; and with some elongated amphibia, *Salamandra maculosa* and *Siredon pisciformis*, eight to twelve lymph hearts exist along the sides of the body and tail, at the junction of the dorsal and ventral body muscles. Finally, in some elasmobranch fishes the number of lymph hearts is very great (Sappey).

Below the birds the lymphatic glands are absent, their place being supplied by lymphoid tissue and by special fine vascular rete or networks into which the vessels break up in their course (Owen has described mesenteric glands in the crocodile). Perfect valves like those present in mammals are found in birds, less perfect ones in reptiles and amphibia, and finally in the fish-like forms none at all are found, so that the system may be injected toward the periphery like the arteries.

Topographical Anatomy of the Lymphatics.—While it would seem more philosophical to treat the various parts of the lymphatic system in their entirety throughout the whole body—viz., the ectal, superficial, or subcutaneous; the ental, subaponeurotic or deep, and the visceral lymphatics with the corresponding glands and lymphoid tissue—it is better practically, both for the purposes of demonstration and study, to consider all the lymphatic structures belonging to a given region at one time. This method is also really in accord with nature, because all the lymphatic structures in any moderately well-defined region of the body are, sooner or later, intimately associated and really form one whole for the given region.

Following the plan ordinarily pursued, the lymphatic vessels will be considered as extending in the direction in which their contents flow as with the veins, and also in order in which they must be demonstrated by injections. This will require the investigation to commence at the periphery and extend toward the centre. In the descriptions here given, usually only the trunks containing valves will be considered. The origin of the vessels in the tissues and the valveless networks will be considered below, under the origin and relations of the lymphatics. When the term plexus is used in this article it will be restricted to a lymphatic plexus composed of lymphatic glands with their connecting lymphatic vessels, and will not apply to a network of vessels without glands. After the vessels of a region have been de-

scribed, there will be given a list of the groups of the lymphatic glands and the plexuses belonging to the region, together with the source and destination of the afferent and efferent vessels. This will serve both to give the proper information concerning the number and position of the glands, and also to form a condensed summary of the lymphatic system in the region.

LYMPHATIC VESSELS OF THE HEAD, FACE, AND NECK.—The ectal or subcutaneous lymphatic vessels of the head and face are very abundant and follow, in general, the course of the occipital, temporal, and facial blood-vessels, converging somewhat toward the great vessels of the neck; they traverse one or more of the lymphatic glands which form an irregular zone nearly around the base of the head (Fig. 3263), and finally enter the internal jugular plexus, and terminate in the thoracic duct on the left, or the common lymphatic trunk on the right (Fig. 3279). In addition to the general description just given, the lymphatics of the eyelids, nose, and ear require special mention.

The lymphatics of the eyelids and palpebral conjunctiva form a very abundant network, although it is somewhat difficult to demonstrate. Those from the conjunctiva wind round the edges of the lids and mingle with those of the integument, which are especially abundant at the edges of the lids. The branches unite into two great groups at the canthi of the lids, those at the lateral canthus extending to the parotid lymphatic glands, while those at the nasal canthus join those from the middle of the forehead and the nose, and extend to the submaxillary lymphatic glands (Fig. 3263).

The skin of the nose, especially the thicker part around the tip, where the large sebaceous glands are so abundant, is possessed of a very dense network of lymph capillaries and minute trunks. These trunks are joined by the abundant lymphatics from the vestibule, which in turn are continuous with the lymphatics of the nasal mucosa. Finally, the collecting trunks from the vestibule and the nasal integument extend obliquely across the face to the submaxillary lymphatic glands.

The lymphatics of the external ear and meatus form three principal groups: 1. Those of the helix, antihelix, and convex (posterior) surface. Those of the helix and antihelix wind round the free border of the ear to the convex surface, where they join the trunks of that surface, and uniting into several (four to five) considerable vessels, they extend to the mastoid lymphatic glands. 2. The lymphatics of the external auditory meatus, also the membrana tympani (see below), the concha and tragus, terminate by two or three trunks in the parotid lymphatic glands. 3. The lymphatics of the lobule unite into seven or eight considerable trunks which extend to the caudal or lower of the mastoid lymphatic glands.

Ental Lymphatics of the Face and Head.—These are exceedingly abundant, and extend mostly to the deep cervical glands, but the relations of the vessels and the terminal glands are so various that a special description is required for each of the principal organs. Nasal cavities and sinuses opening into them: The existence of lymphatic vessels in the nasal mucosa was not demonstrated until 1859, when E. Simon showed by successful puncture injections that they were numerous. He also showed their relation with the network of the nasopharynx. The existence of these vessels has been verified by Sappey in man and numerous animals. According to Sappey, the demonstration is comparatively easy wherever the mucosa is of considerable thickness. Schwalbe, and later Key and Retzius, showed that the nasal lymphatics could be injected from the subdural space; Key and Retzius [2] further showed that the injection was equally successful from the subarachnoid space of the brain, the subarachnoid and subdural spaces of the myel (spinal cord). They also found that while in most cases the perineural sheaths of the olfactory nerves were injected at the same time, yet true lymphatic vessels did not communicate with these, but had special passages through the lamina cribrosa, and were often injected when the perineural sheaths were not injected; and sometimes the perineural sheaths were injected without the injection of the lymphatics. They were not successful in injecting the nasal lymphatics of man from the cranial lymph spaces, although the perineural sheaths of the olfactory nerves were in some cases filled. The freshly sacrificed dog and rabbit furnished the most successful preparations. The lack of success in man was

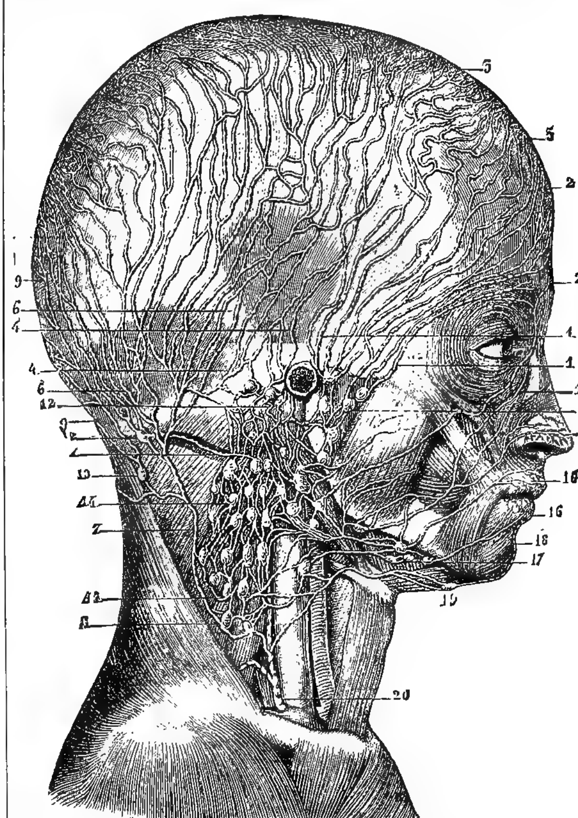


FIG. 3263.—Ectal Lymphatics of the Head and Face, the Ental Lymphatics of the Neck, and the Right Common Lymphatic Trunk. (Sappey [1].) 1, Lymphatics from the frontal region going to the parotid lymphatic glands; 2, 2, vessels arising near the middle of the forehead, the upper ones going to the parotid, the lower ones to the submaxillary lymphatic glands; 4, 4, vessels from the parietal and temporal region extending to the mastoid lymphatic glands; 6, 6, vessels from the parietal and occipital region joining the occipital plexus; 7, trunk from occipital plexus to the supraclavicular glands; 8, trunk from the occipital to the cephalic ental (superior deep) cervical glands; 10, 10, occipital lymphatic glands; 11, cephalic ental (superior deep) cervical glands and plexus; 12, mastoid glands; 13, parotid lymphatic glands; 14, part of supraclavicular glands; 15, 15, lymph vessels from the nose to the submaxillary glands; 16, 16, lymphatics from the lips to the same glands; 17, submaxillary glands; 18, vessel from the lip to 19, the supra-hyoid gland; 20, right common lymphatic trunk opening into the veins at the angle formed by the junction of the subclavian and internal jugular veins.

attributed to the inability to obtain sufficiently fresh material; it was also suggested that in man the lymph from the cranial lymph spaces might have a sufficient number of other outlets.

The lymphatic network covers the entire nasal mucosa, both on the olfactory and the respiratory part, and that lining the septum. In man this network is directly continuous with that of the vestibule of the nose, but the collecting trunks extend toward the pharynx. The network is also continued into the frontal, and presumably the other, sinuses opening into the nasal fossæ. As they approach the pharynx, the collecting trunks of the nasal mucosa are continuous with those of the dorsal surface of the soft palate and of the pharynx, especially the dense network around the Eustachian orifice. From

these situations the collecting trunks accompany those of the soft palate and the pharynx, sending one trunk through the wall of the pharynx to the large lymphatic gland ventrad of the atlas. This gland, according to Sappey, is the most cephalic (superior) of any in the body, and becomes involved in diseases of both the nose and the pharynx. The other trunk traverses the pharyngeal wall, and extends along the neck to the level of the perforation of the sterno-mastoid muscle by the accessorius nerve, where it bifurcates and enters the two deep cervical glands, covered by the sterno-mastoid muscle at this point. No doubt, also, minute branches join the palatine trunks which follow the posterior pillars of the fauces, and enter the deep cervical glands near the thyrohyoid ligament (Plate XLII., 13). In the dog all the lymphatics from the nasal mucosa are shown by Key and Retzius as entering the deep cervical glands (3, 3, of Fig. 3285). Sappey figures and describes the exceedingly abundant lymphatics of the nasal mucosa in the horse and ox. In both these animals, but especially in the horse, the lymphatics of the mucosa lining the nasal septum are very abundant, and in both animals, besides the trunks extending toward the pharynx, there are large trunks extending toward the prenares, where they become subcutaneous, and extend with the ectal facial vessels to the submaxillary lymphatic glands.

Lymphatics of the Eye and the Orbit.—The lymphatics of the palpebral conjunctiva wind round the edge of the eyelid, and join those of the integument as described above, and finally reach the parotid and submaxillary lymphatic glands. Sappey denies the presence of lymphatics in the eyeball itself, but most anatomists consider that, while the eye may not be supplied with numerous independently walled lymphatics, nevertheless it is abundantly supplied with lymph passages, etc., many of which have an endothelial lining. The lymph channels of the cornea, which are exceedingly abundant, following the nerves as well as the corneal corpuscles and their co-anastomosing processes, communicate with the conjunctival vessels, and also with the lymph clefts of the sclerotic; the aqueous chamber also communicates indirectly with the conjunctival lymphatics through the cornea. In the suprachoroidea have been described distinct anastomosing lymphatic vessels by Altmann, and their presence has been lately confirmed by one of his pupils.[3]

The retinal blood-vessels are well supplied with perivascular lymph spaces like those of the central nervous system, and may be injected from the lymph spaces of the optic nerve. Both chambers of the eye and the perichoroidal, and the space enclosed by the capsule of Tenon, and the lymph spaces of the optic nerve, all communicate; and as shown above, the corneal spaces, and the aqueous chamber through the cornea, communicate on the one hand with the conjunctival lymphatics, and on the other with the lymph clefts in the sclerotic. In accordance with this complicated relation of the lymph paths of the eye, the lymph streams have been likewise found of equal complexity—passing from the vitreous to the papilla optici, and along the central canal of the optic nerve with the blood-vessels, and ultimately reaching the cranial cavity. This has been shown to be the direction in the cat, dog, rabbit, and guinea-pig, and is supposed to be also the case in man. There is also a stream flowing from the subarachnoid and subdural spaces in the cranium, which follows the prolongations of those spaces around the optic nerve; these finally reach the eye and communicate with its various lymph spaces, and through the perichoroid space with the lymph space in the capsule of Tenon, and presumably through this with the lymphatic vessels in the orbit. That is, there is a lymph stream flowing from the eye to the cranial cavity, and another from the cranial cavity back to the eye through a different channel.[4] If the assumption is correct, that the lymphatics of the eyeball communicate through the capsule of Tenon with the lymphatics of the structures in the orbit, their destination is to the lymphatic glands of the ental cervical group in the sphenomaxillary fossa. Through the cranial cavity the lymph from the eye might also extend with the lymph of the subarachnoid and subdural spaces to any point with which these spaces communicate. (See lymphatics of the central nervous system, below.)

Lymphatics of the Ear.—The lymphatics of the membrana tympani are like the blood-vessels in three layers, corresponding to the cutis, the mucosa, and the intermediate fibrous framework. They extend to the external auditory meatus and, joining these, finally enter the parotid lymphatic glands, as described above for the external ear. Those of the tympanum or middle ear are numerous, but apparently confined mostly to the submucosa. They are directly continuous with the lymphatics of the Eustachian tube, and extend with them to the abundant network in the pharynx around the Eustachian orifice, and finally extend to the ental cervical lymphatic glands. The lymphatics of the internal ear consist mostly of spaces which are in communication with the subarachnoid and subdural spaces through the perineural spaces of the auditory nerve, thus agreeing with the eye and nose.

Lymphatics of the Mouth, Pharynx, and Larynx.—The immense richness of the lymphatic network in these regions, their connection with the nose, and through the

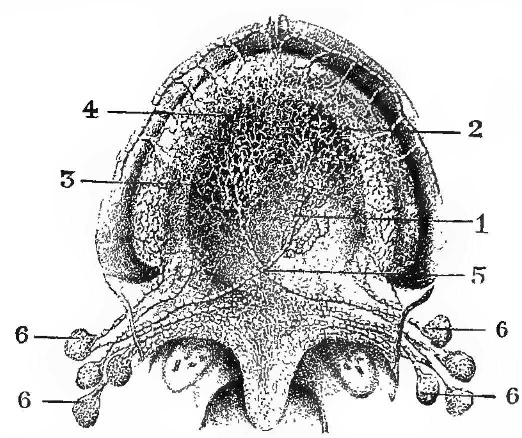


FIG. 3264.—Lymphatics of the Roof of the Mouth and the Gums in a Child at Birth. (Sappey, Atlas.) 1, The lymphatics injected by one puncture at 2; the trunk formed on the right crosses to the left, and those from the left to the right. Crossings of the lymphatics in man are most frequent in this situation, according to Sappey. In the lower animals such intercrossing is not infrequent; 2 and 4 point where the cannula was inserted to make the injections; 3, lymphatics of the gums, connected on one side with those of the palate and on the other with those of the cheeks, the trunks usually extend with those of the cheeks to the submaxillary lymphatic glands, those nearest the parotid lymphatic glands frequently enter them instead of going to the submaxillaries; 5, crossing point of the trunks from the roof of the mouth; 6, 6, group of ental cervical glands near the bifurcation of the common carotid.

nose with the cranial lymph spaces, with the middle ear, œsophagus, and trachea, and the varied termination of the collecting trunks, give the lymphatics of this group an especial anatomical interest. They are not less important pathologically from their involvement in the grave disorders of the mouth, nose, and throat.

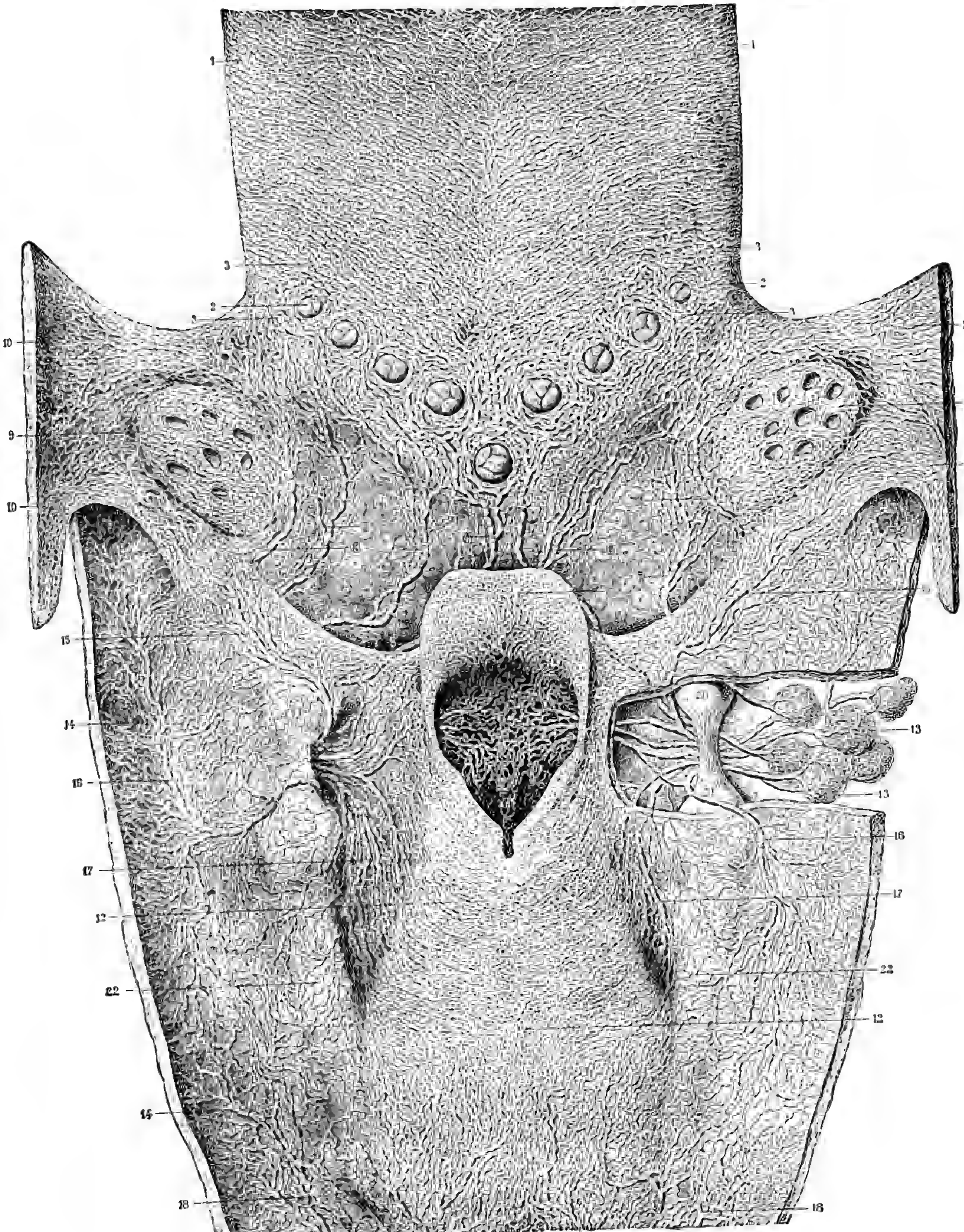
The lymphatic network of the buccal mucosa, gums, roof, and floor of the mouth, palate, and pharynx, may be said to be continuous, but the collecting trunks in different regions have quite different destinations. At the lips the network is also continuous with that of the integument, but the course of the lymph stream is away from the lips. For the gums of the maxilla or upper jaw, the lymphatics extend between the teeth and join those of the mucosa of the cheek; these follow in general the contour of the jaw and penetrate the cheek at various points, extend in part to the parotid lymphatic glands, but mostly to the submaxillary glands. Nearer the pharynx they join the palatine lymphatics (Fig. 3264). A large number of those from the gums of the

EXPLANATION OF
PLATE XLII.

EXPLANATION OF PLATE XLII.

Which Represents the Base of the Tongue, the Tonsils, the Pharynx, and the Opening of the Larynx of Man. The Pharynx was Divided on the Dorsal Side, and the Walls were Reflected. (Sappey, "Atlas.")

1, 1, Lymphatic network on the dorsum of the tongue, the general direction of the vessels is obliquely toward the raphe (meson) and the base of the tongue; 2, 2, circumvallate papillæ in the form of a **V**; 3, 3, 3, 3, vessels surrounding these papillæ and soon converging to form mesal and lateral trunks; 4, 4, lymphatic trunks extending along the meson from the middle circumvallate papilla; 5, 5, continuation of 4, one on each side of the middle glosso-glottic fold, and finally penetrating the lateral fold, they enter the lymphatic glands (13) of the ental cervical plexus near the lateral thyro-hyoid ligament; 6, 6, other trunks farther from the meson, taking the same course; 7, 7, lateral trunks from the base of the tongue, tonsil, etc.; they penetrate the pharyngeal mucosa and terminate in the same group of glands, but cross the dorsal instead of the ventral surface of the great cornu of the hyoid; 8, 8, trunks coming from the anterior pillars of the fauces, skirting the edge of the tonsils, and finally entering the cephalic, ental (superior deep) cervical lymphatic glands; 9, 9, the tonsils, covered by a dense network of lymphatics; 10, 10, 10, 10, the reflected sides of the arch of the palate (just below the "10" on each side is the divided uvula); 11, dense lymphatic network covering the epiglottis and extending upon the aryteno-epiglottic folds; 12, 12, a similar very dense and fine network of lymphatics upon the pharyngeal mucosa covering the larynx; 13, 13, several lymphatic glands belonging to the cephalic, ental (superior deep) cervical lymphatic glands, situated at the level of the thyro-hyoid ligament; as is evident from the plate, they receive the trunks from the base of the tongue, part of the palatine arch, the tonsils, the larynx, and a great part of the pharynx; 14, lymphatics arising from the ventral and lateral part of the pharynx; 15, 15, lymphatics from the posterior pillars of the fauces, they wind round the ventral edge of the great cornu of the hyoid and enter the deep cervical glands at 13, 13; 16, 16, lymphatics arising from the dorsal and lateral aspect of the pharynx and extending to the cervical glands at 13, 13; 17, 17, lymphatic trunks on each side of the larynx to the ental cervical glands at 13, 13; 18, 18, lymphatics from the dorsal and lateral wall of the pharynx next the œsophagus, they extend toward the thorax and enter the chain of ental cervical glands along the trachea and œsophagus; 19, 19, lymphatics from the ventral part of the pharynx, and extending to the chain of ental cervical glands in company with 18; 20, summit of the great cornu of the hyoid exposed by the removal of the pharyngeal wall; 21, end of the major horn of the thyroid, connected with the hyoid by the thyro-hyoid ligament; 22, 22, dorsal border of the thyroid cartilage showing through the pharyngeal wall.



BASE OF THE TONGUE, THE TONSILS, PHARYNX, AND OPENING
OF THE LARYNX OF MAN
(SAPPEY, ATLAS)

lower jaw join the lymphatics of the cheek and extend to the submaxillary lymphatic glands. A part also join those of the pillars of the fauces.

The lymphatics of the hard and soft palate, while directly continuous with those of the gums, have a direction toward the pharynx, the trunks of the two sides often crossing. They join those of the pillars of the fauces, and go with them to the ental cervical glands near the larynx (Fig. 3264; Plate XLII.). Some also extend to the glands near the bifurcation of the common carotid with the trunks from the soft palate (Fig. 3264). The lymphatics of the soft palate on the pharyngeal or superior surface are only moderately developed, and communicate with those from the nose and from the Eustachian tube; the collecting trunks extend in part along the posterior pillar of the fauces to enter the glands along the larynx (Plate XLII., 13). But a greater number of collecting trunks pass laterad and penetrate the pharyngeal walls to enter the gland on the ventral aspect of the atlas. The ventral or lower face of the soft palate differs from the dorsal or upper face in having a greater number of lymphatic vessels, and the uvula is so richly supplied that it appears almost like erectile tissue, increasing two or three times in volume when successfully injected. The collecting trunks from the uvula and ventral aspect of the soft palate extend along the two pillars of the fauces, and join the trunks from the base of the tongue; but the greater number pass laterad through the wall of the pharynx and extend to the ental cervical lymphatic glands around the bifurcation of the common carotid.

The lymphatics of the tongue escaped discovery until 1847, when Sappey demonstrated them. They are difficult to demonstrate in the adult on account of the number and calibre of the veins, but in the infant and child the veins cause less trouble, and the lymphatics are easily injected. They form a rich network over the entire free surface to a point slightly beyond the circumvallate papillæ. Around the circumvallate papillæ they reach their greatest development. Up to the present no lymphatics have been demonstrated as arising in the substance of the tongue itself, the vessels traversing the tongue being collecting trunks from the mucosa. Around the edges of the tongue the network of the dorsal and ventral surfaces freely anastomose. But the main course of the collecting truncules is toward the middle, on the dorsal side, and toward the base. A few small trunks penetrate the tongue and after traversing the lingual glands, when those are present, extend to the ental cervical glands near the bifurcation of the common carotid. Most of the trunks, however, continue along the dorsum of the tongue, unite into large trunks beyond the circumvallate papillæ, and extend in a wide curve to the ental cervical lymphatic glands situated near the thyro-hyoid ligament (Plate XLII., 13). The lymphatics on the ventral side of the tongue extend mostly through the substance of the organ, traversing the lingual glands when present, and finally extend with those which penetrate from the dorsal side, to the lymphatic glands around the bifurcation of the common carotid.

The tonsils, although composed of lymphoid tissue, were not shown to possess a lymphatic network until Sappey succeeded in demonstrating it, in 1876. This network, which covers the surface and extends into the depths of the tissue, is much more easily injected in the new-born child than in the adult. The network anastomoses with that of all the surrounding structures, and the collecting trunks pass with those from the tongue and pillars of the fauces to the glands next the thyro-hyoid ligament (Plate XLII.). The lymphatics of the pharynx also resisted demonstration for a long time. They were found by Sappey to be directly continuous with those of the bordering structures, and while the trunks all communicate at their origin, there are three groups on each side: 1. A dorsal group extending along the dorsal or posterior wall of the pharynx nearly to the postnares, and then turning laterad and penetrating the pharyngeal wall, enters the gland on the ventral side of the atlas. 2. Several lateral trunks which extend along the side of the larynx and enter the lymphatic glands near the thyro-hyoid ligament. 3. Several ventral trunks extending mostly in a caudal (inferior) direction to join the supraclavicular lymphatic glands along the œsophagus and trachea.

Larynx.—The lymphatics of the larynx form one of the densest networks known in the body. Commencing with the epiglottis the number is almost infinite, the appearance being as if all the soft structures were composed of nothing but lymphatics. With the infant the abundance of lymphatics is continued without interruption along the trachea; but as age advances, the network in the larynx quite suddenly diminishes, so that, commencing with the vocal cords, the network in the larynx and trachea is comparatively slight. From the epiglottis, vestibule of the larynx, the sinus or ventricle, and the vocal cords, collecting trunks extend through the lateral wall of the vestibule, perforate the thyro-hyoid membrane, and terminate in the ental cervical glands beside the larynx (Plate XLII., 13).

Lymphatics of the Central Nervous System.—The spaces and membranes of the brain and the myel are so directly continuous that a discussion of the lymphatics of both seems desirable. Sappey denies lymphatics to the entire nervous system, both central and peripheral, but this is not in accordance with most observers who have made special investigations upon the subject. It is true that independent vessels with definite walls are not found to exist in the nervous substance proper; but from the investigations of Kölliker, Virchow, Robin,[5] and Key and Retzius, it has been shown that, in the nervous substance of the brain and myel, the blood-vessels ramifying in it are possessed of a loose adventitia which is continued from the pia, the so-called pial funnels; and in the meshes of this adventitia are long spaces, like those around the blood-vessels of reptiles. It is supposed that these communicating spaces form the lymph passages of the nervous substance. They may be injected for a considerable distance into the nervous substance from the subarachnoid space, and injections by the puncture method into the nervous matter not infrequently fill these passages, and extend into the subarachnoid space. After reviewing carefully all the evidence, Key and Retzius[2] consider the perivascular space of His—that is, a space entirely outside all the walls of the blood-vessel —as an artifact, as is also the presence of a subpial lymph space into which it opens. From the standpoint of Key and Retzius, then, the nervous matter of the central nervous system is drained of its lymph through the adventitial lymph spaces of its blood-vessels, and these spaces open into the subarachnoid space.

The lymphatics of the meninges are still in some doubt. In the dura there are wide-meshed, often ampulliform, vessels with endothelial walls that are supposed by some to be true lymphatics. Although their form is so strikingly like lymph vessels, Key and Retzius found, on making the crucial test, that they communicate with the blood-vessels and do not extend to lymphatic glands. There are, however, in the dura a great number of elongated clefts which are probably lymph clefts or channels. In the pia a very distinct and undoubted network of lymph vessels has been described and figured. It is probably largely through these that the lymph of the subdural and subarachnoid spaces is drained away.

The subarachnoid space communicates directly with the neurocœle (ventricles of the brain) through the foramen of Magendie, and both the subarachnoid and subdural spaces of the optic, auditory, and olfactory nerves, and, in fact, all the nerves arising from the brain and myel, except that in the ordinary nerves the arachnoid as a special membrane soon disappears, and the subdural and subarachnoid spaces become one.

The ento-cranial lymphatics converge to form larger and larger trunks. Those from the vascular plexuses or telas accompany the *vena magna Galeni* to the base of the brain, where they are joined by the lymphatic trunks

from the surface of the brain. The combined trunks follow the great blood-vessels out of the cranial cavity mostly through the jugular foramen, and enter the deep cervical lymphatic glands. Small trunks are described as traversing the spinous and oval foramina with the middle meningeal vessels, finally to enter the ental cervical glands in the spheno-maxillary fossa; but the existence of these lymphatic trunks is disputed.

As stated, the subarachnoid and subdural spaces of the brain are directly continuous with the corresponding spaces of the myel, and are also projected out with the nerves, most completely with the optic, auditory, and olfactory, and in this way communication is gained with the lymphatics of the structures to which the nerves are distributed.

The exact relations of the ento-spinal lymphatics do not seem to have been well worked out, but they are described as following the blood-vessels, and terminating in the glands in course of the blood-vessels which they follow. The lymphatics of the central nervous system then extend to all great groups of glands in the neck and trunk.

Lymphatics of the Neck.—These are ectal and ental (superficial and deep), and include the lymphatics of the structures of the neck proper, and also all the trunks from the head and face. The vessels from the integument extend mostly to the ectal cervical glands, but part of them enter the supraclavicular glands directly (29, 29, of Fig. 3269).

LYMPHATIC GLANDS OF THE HEAD AND NECK.—These are very numerous and important. They are all con-

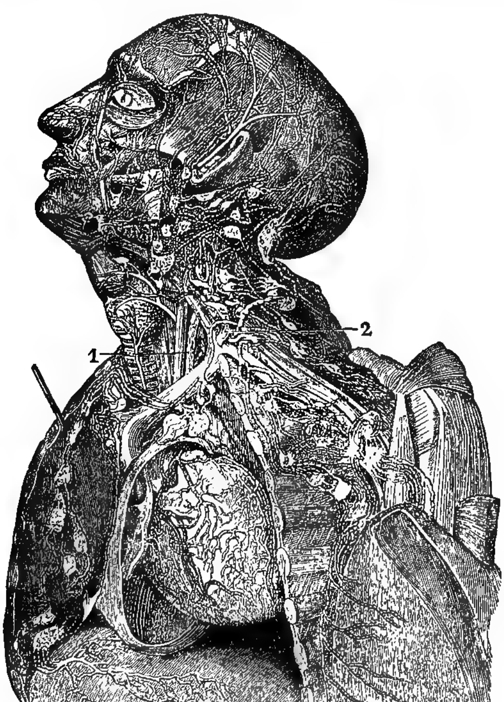


FIG. 3265.—General View of the Head, Neck, and Thorax, also the Termination of the Thoracic Duct. (Mascagni.) 1, Thoracic duct as it emerges from the thorax opposite the first rib; 2, termination of the thoracic duct at an angle formed by the junction of the subclavian and internal jugular veins. In the original folio plate there is a considerable swelling shown on the thoracic duct about 15 mm. before its termination. At the lower part of the figure is the arching diaphragm with vessels extending to the sternal glands; the heart is displaced to the left from the opened pericardium. This cut does scant justice to the beautiful original, in which every detail is clear and clearly marked by letters or numerals.

fined to the sides of the face, around the base of the head, none having been found within the skull, and along the great cervical blood-vessels. They have been divided into two great paired groups or plexuses, the ectal or external, and the ental or internal jugular lymphatic plexuses; the ectal jugular plexus including all the ectal glands and finally pouring its lymph into the ental plexus, which includes all the ental cervical glands. This, while communicating with the glands in the thorax and axilla, sends a main efferent trunk, *truncus jugularis*, to join the thoracic duct on the left, the common lymphatic trunk on the right; or in some cases the jugular trunk ends partly or wholly independently in the veins (4 and 5 of Fig. 3283). These plexuses form a kind of double and closely connected chain along the course of the great cervical vessels, and yet, for convenience of description and reference, they have been described as several groups; but here, as in other parts of the body of man, the groups merge so insensibly into each other that the same gland might be placed in one group by one anatomist, and in the adjoining group by another. Furthermore, it should not be lost sight of that from a limited region lymphatics may go to quite widely separated groups of glands, and also that the number and size of the glands in a group are subject to considerable individual variation. (For examples, see Fig. 3268 B. and 3276, also the description of the lymphatics of the liver, Fig. 3273.)

The ectal glands of the head and neck, *i.e.*, the glands of the ectal or external jugular lymphatic plexus, are divided into the five following groups:

1. The occipital lymphatic glands (*glandulæ lymphaticæ occipitales, s. suboccipitales*), one or two, usually small glands on the complexus muscle between the cranial attachment of the trapezius and the sternomastoideus. The afferent vessels are from the occipital, partly, also, from the temporal and parietal regions; the efferent vessels extend partly to the ectal cervical, and partly to the supraclavicular glands (Figs. 3263 and 3265).

2. Parotid lymphatic glands (*glandulæ lymphaticæ parotideæ, s. auriculares anteriores, s. faciales superficiales, s. zygomaticæ*). There are usually ten to twelve of these on the surface and in the substance of the parotid salivary gland. The afferent vessels are from the temporal and frontal regions, the sides of the face, lateral part of the eyelids and conjunctiva, concha, tragus, membrana tympani and external auditory meatus of the ear; from part of the mucosa of the cheeks and the gums of the maxilla or upper jaw. The efferent vessels pass to the submaxillary and ectal cervical lymphatic glands.

3. Mastoid lymphatic glands (*glandulæ lymphaticæ mastoideæ, s. subauriculares, s. auriculares posteriores*). Several small glands on the cranial attachment of the sternomastoid muscle, near the mastoid process and base of the ear. The afferent vessels are from the parietal, temporal, and occipital regions in part, from the helix, antihelix, convex surface, and lobule of the ear. The efferent vessels extend to the ectal and ental cervical glands.

4. Submaxillary lymphatic glands (*glandulæ submaxillares*). There are several of these extending along almost the entire extent of the body of the mandible. In this group are included the glands on the buccinator muscle, sometimes described as a separate group (glandulæ buccales, s. buccinatores) and sometimes classed with the ental glands. The submaxillary glands extending near the chin are also sometimes called submental, and a single one near the meson has been named suprahyoid by Sappey. The afferent vessels of this group are from the middle of the forehead, the nasal canthus of the eye, the integument of the nose and vestibule, and in the horse and ox also partly from the nasal fossæ; from the cheeks and lips, the gums of the mandible in part, and the floor of the mouth, part of the efferent vessels from the parotid lymphatic glands; the efferent vessels pass to the ectal and ental cervical glands.

5. Ectal cervical lymphatic glands (*glandulæ lymphaticæ cervicales ectales, s. superficiales, s. jugulares superficiales*). Several small glands along the ectal jugular vein, but extending on both sides of it. They are between the platysma and the sternomastoid muscles. The afferent vessels are from the ectal structures of the neck, part of

Lymphatic System.

the efferent vessels from the occipital, parotid, mastoid, and submaxillary groups; efferent vessels extend to the supraclavicular glands.

The ectal or external jugular lymphatic plexus in the larger animals—horse and ox—is approximately like that of man; but in the rabbit it is represented only by the submaxillary lymphatic glands and two small glands near the ear (3 and 4 of Fig. 3286). In the dog only the submaxillary lymphatic glands seem to belong to this plexus (3 of Figs. 3281 and 3284); in the cat the mastoid glands are large and may be injected from the inner or concave aspect of the external ear. It is possible that the small gland on the trunk following the external jugular vein, shown in Fig. 3282, may also belong to the ectal plexus. One cannot help being struck with the fewness of the glands in the dog, cat, and rabbit.

The ental glands of the head and neck, or the glands of the ental jugular plexus are situated on the course of the great vascular trunks and extend from the atlas to the thorax. The lymphatics of the entire head and neck ultimately traverse this plexus.

The glands of this plexus have been quite commonly divided into three great groups, with some minor groups —the deep facial, the superior and inferior deep cervical; but in actual descriptions of the lymphatics of the various organs the anatomists of the present day, although they recognize three groups, and some of them minor groups, actually divide all the glands of the ental jugular plexus into two groups, viz., those extending from the level of the base of the cranium, along the deep vessels, to the bifurcation of the common carotid, and those from the bifurcation of the carotid to the junction of the jugular and subclavian veins. This division was adopted in the previous description, and has been called (1) ental cervical, and (2) supraclavicular. (1) Ental cervical lymphatic glands (*glandulæ lymphaticæ cervicales entales, s. profundæ, s. glandulæ lymphaticæ jugulares cephalicæ*). The ental cervical, or jugular group of glands, includes all the ental glands around the deep structures from the bifurcation of the common carotid artery nearly to the base of the skull, and includes the glands on the internal maxillary vessels in the sphenomaxillary fossa, which are usually given a separate group under the name of deep facial or internal parotid, internal maxillary, etc. It also includes the glands generally grouped as the superior jugular or superior deep cervical.

The glands in this group are numerous and quite widely separated from one another, extending from the ventral face of the atlas to the side of the larynx, being about as variously arranged as the organs of this region. The one between the atlas and pharynx is said to be the most cephalic of all the lymphatic glands of the body.

The afferent vessels of this group are from the orbit, nasal cavity, the cheek, roof and floor of the mouth, in part from the tongue, pharynx, tonsil, tympanum, and Eustachian tube, the larynx, the thyroid, and the brain and its membranes. The efferent vessels pass to the supraclavicular glands.

(2) The supraclavicular glands (*glandulæ lymphaticæ supraclaviculares, s. cervicales profundæ inferiores, s. jugulares inferiores*). These glands are arranged along the carotid artery and internal jugular vein from the bifurcation of the common carotid to the junction of the subclavian and internal jugular veins. All the efferent trunks from the ectal jugular plexus and from the ental cervical glands enter this group, also many of the lymphatics of the pharynx, œsophagus, trachea, the lymphatics accompanying the vertebral artery and vein, also some of the ectal and ental lymphatics of the neck and the clavicular region. They also communicate with the anterior mediastinal and with the axillary glands. The efferent vessels form a single or multiple trunk (*truncus lymphaticus jugularis*) and terminate on the left in the thoracic duct, or on the right in the right common lymphatic trunk, or sometimes partly or wholly by an independent opening into the great veins (Figs. 3263 and 3283).

In the horse and ox the glands of the neck are approximately like those of man; but in the cat, dog, and rabbit there is but a single ental cervical lymphatic gland, and the jugular trunk is usually large and long, and not infrequently opens partly or wholly into the vein independently (Figs. 3282, 3283, 3285, and 3287).

Lymphatic Vessels of the Thoracic Limb (Arm and Shoulder). —The lymphatics of the arm and shoulder form an ectal and ental set, as in most parts of the body. The lymphatics of the hand arise by a complex network on the dorsal and palmar surface of the fingers, and extend toward each side of the finger, where they unite into two or three anastomosing trunks which follow the direction of the collateral arteries to the hand when they reach the dorsal surface. From the palm many vessels wind round both edges to the dorsal side also; but many next the wrist extend directly upon the ventral or flexor aspect of the arm and extend to the axillary region. The trunks on the dorsum of the hand and the extensor side of the entire arm gradually wind round to the flexor surface in their course to the axilla. Most of the vessels enter directly the axillary glands, but a few of those from the fourth and fifth fingers and the ulnar side of the antibrachium traverse one or two glands (ectal brachial or supra-epitrochlear glands in the flexure of the elbow, Fig. 3267) before proceeding to the axillary glands. Frequently, if not constantly, one or more trunks follow the cephalic vein and go to the subclavian glands instead of going to the axilla, and not infrequently there is a gland in the course of these near the insertion of the deltoid, or even farther along (13 of Fig. 3267; see also Fig. 3269). The ectal lymphatics of the shoulder either join the trunk following the cephalic vein or extend round to the axilla. The ental lymphatics of the arm arise in the deep structures and follow the principal blood-vessels much more closely than do the ectal lymphatics. In the antibrachium there are, therefore, three groups following the radial, ulnar, and interosseous blood-vessels. There are occasionally a few small lymphatic glands in the antibrachium (antibrachial glands) through which a part of the vessels pass; but usually none are reached until in the flexure of the elbow, where, extending along the brachial vessels, there are regularly met three or four glands (ental or deep brachial glands), which most of the vessels traverse. Before reaching the axillary glands, according to most authors, there is a free anastomosis between the ectal and ental lymphatics at the wrist and elbow, but Sappey denies any such anastomosis.

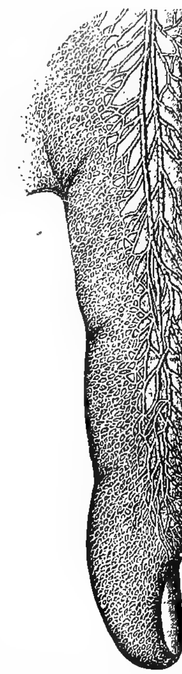
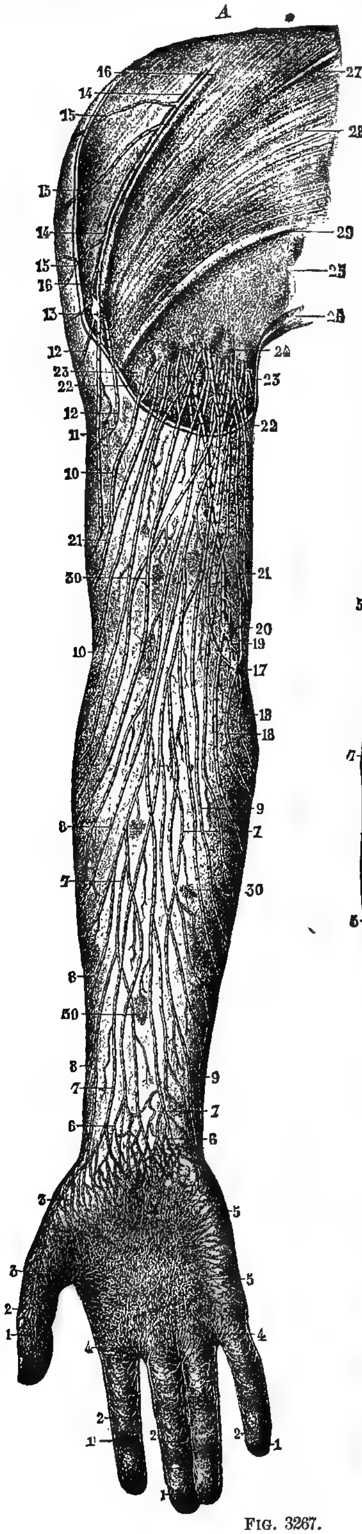


FIG. 3266.—Ectal Lymphatics of a Finger. (Sappey.) To show the extreme abundance of the lymphatics and the fineness of the network on the end and the palmar aspect, also that the vessels from both the dorsal and ventral surfaces extend to the side where two or three considerable trunks, parallel with the collateral artery, convey the lymph toward the hand. By comparing Fig. 3267, it will be seen that these trunks always extend upon the dorsum of the hand.

According to the description of most veterinarians, the lymphatics of the arm and shoulder of the horse and ox are quite comparable with those of man both as to glands and vessels, except that there is a larger lymphatic gland in the fold between the scapula and the neck—the prescapular gland. In the dog and cat the arrangement is exceedingly simple. All of the vessels, except a few cutaneous ones whose course is somewhat irregular,

which can be injected from the pads of the manus (fore-paw), finally extend upon the dorsum of the paw, and extend from there by two or more frequently anastomosing trunks along the radial nerve to the elbow, and then follow the cephalic vein to the prescapular gland, no axillary glands being present (Figs. 3281 and 3284). Occasionally, in the cat, one or more branches turn in the bend of the elbow to follow the brachial vessels to the axilla, and finally enter the nearest pectoral gland.



In the rabbit, vessels likewise follow the radial nerve to the elbow, then extend obliquely around the radial side of the brachium to the axillary glands. Other trunks follow the large blood-vessels, and enter the axillary glands. The lymphatic vessels of the arm, whatever their course, traverse but a single gland in the dog and cat, sometimes two glands in the rabbit.

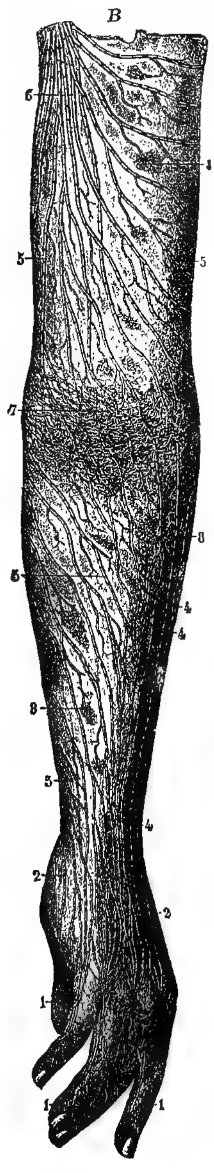


FIG. 3267.

LYMPHATIC GLANDS OF THE ARM AND SHOULDER.—Ectal brachial glands (*glandulæ brachiales ectales, s. superficiales, s. cubitales superficiales, s. supratrochleares*), two glands often found in the course of part of the trunks from the fourth and fifth fingers and the ulnar side of the arm. The gland in the course of the trunk following the cephalic vein has not been named.

The ental glands. There are sometimes a few in the antibrachium (*glandulæ lymphaticæ antibrachiales*), through which traverse the ental antibrachial lymphatics, on their way to the ental brachial glands (*glandulæ lymphaticæ brachiales entales, s. profundæ, s. cubitales profundæ*). These are just proximal of the elbow-joint on the brachial vessels. Through them pass part of the ental lymphatics.

The axillary lymphatic glands (*glandulæ lymphaticæ axillares*, Fig. 3269) are situated in the axillary region around the great vessels and nerves, and covered by the pectoral muscles and extending from the edge of the great pectoral into the subclavian fossa, where they are in communication with the supraclavicular glands. All the lymphatic vessels of the arm and most of those of the shoulder enter these glands; also many from the supra-umbilical part of the abdomen, side, and back; also the lymphatics of the mammary gland and the other structures of the breast, including the efferent vessels of the pectoral lymphatic glands. The efferent trunk (*truncus*

FIG. 3267.—Ectal Lymphatics of the Hand and Arm. (Sappey, Atlas.) To show the number and course of the trunks, and the fineness of the network in the hand and arm. Except a small area around the shoulder and in the axilla where the skin is removed, the lymphatics are represented as if the skin were transparent. *A*, Ventral aspect of the right arm. 1, 1, Network of lymphatics on the palmar aspect of the fingers; 2, 2, the collateral trunks on each side of the fingers—the collecting truncules from both palmar and dorsal side wind round the finger to the edge and, uniting into two or more trunks (Fig. 3266), extend upon the dorsum of the hand; 3, 3, trunks coming from the palm to join those from the thumb; 4, 4, collecting trunks from the distal part of the palm which wind round between the fingers to reach the dorsal surface (see *B*); 5, 5, collecting trunks at the ulnar side of the hand, likewise winding round upon the dorsal surface; 6, 6, collecting trunks from the palm next the wrist—they extend directly along the flexor aspect of the arm; 7, 7, large trunks formed by the union of many of those from the palm and thumb; 8, 8, trunks winding round the radial side of the antibrachium from the extensor to the flexor side; 9, 9, similar trunks winding round the ulnar side of the antibrachium, from the dorsal or extensor to the ventral or flexor side; 10, lymphatic trunks curving round from the dorsal or extensor to the ventral or flexor side of the brachium to enter the axillary glands; 11, trunk following the course of the cephalic vein and traversing the gland at 13; 12, 12, trunks winding round the arm and shoulder to join the gland on the cephalic vein; 14, 14, lymphatic trunk accompanying the cephalic vein and entering the subclavian glands; 15, vessels from the scapular region to the trunk accompanying the cephalic vein; 16, cephalic vein in the furrow between the deltoid and pectoral muscles; 17 and 20, ecto-brachial or supra-epitrochlear lymphatic glands—through these pass part of the vessels from the little finger and the ulnar side of the arm; 18, 19, trunk entering the more distal and joining the two glands—the efferent trunk from 20 is one of the largest of the arm, it penetrates the tissues and accompanies the basilic vein to the axillary glands; 21, 21, collecting trunks extending toward the axilla; 22, 22, cut edge of the skin; 23, 23, brachial aponeurosis; 24, axillary lymphatic glands showing through the aponeurosis; 25, axillary aponeurosis covering the glands; 26, border of the axillary space formed by the teres and latissimus muscles; 27, clavicular fascia of the pectoralis separated from the deltoid by the groove containing the cephalic vein with its accompanying lymphatic trunk; 28, sternal fascia of the pectoralis; 29, border of the pectoralis, forming also the border of the axilla; 30, 30, 30, points on the brachium and anti-brachium where the fine network of vessels has been injected—in a completely injected preparation the entire skin would be covered with such a network. *B*. Ulnar side of the hand and extensor aspect of the antibrachium and part of the brachium, to show that the trunks from the fingers and palm extend largely upon the dorsal aspect and then wind round the arm to reach the ventral or flexor aspect. 1, 1, 1, Lymphatics of the fingers, the collecting trunks extending upon the dorsum of the hand; 2, 2, vessels on the dorsum of the hand; 3, 3, lymphatic trunks winding round the ulnar side of the antibrachium to reach the flexor aspect; 4, 4, 4, vessels winding round the radial side of the antibrachium to reach its flexor surface; 5, 5, vessels on the brachium curving round to the axilla; 6, group of vessels converging toward the axillary lymphatic glands; 7, lymphatic network at the convexity of the elbow; 8, 8, 8, spots in which the fine lymphatic network of origin is shown.

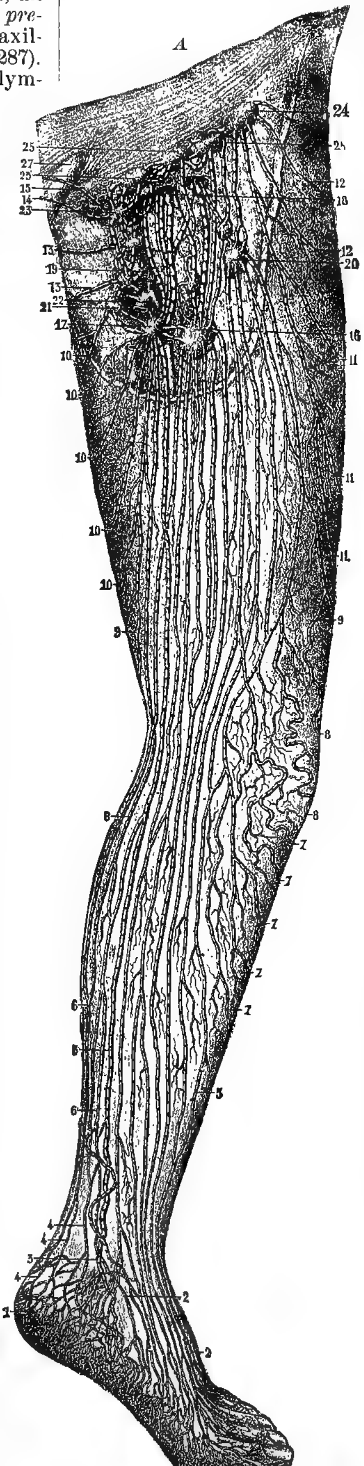
subclavius) is one of the important tributaries of the common lymphatic trunks. As here used the axillary group of glands includes the subclavian or infraclavicular glands into which flow the trunks following the cephalic vein. By some authors the pectoral glands are also included in the axillary group (Quain).

In the dog and cat no axillary glands are present, all the trunks going to the prescapular gland (*glandula prescapularis*) (Figs. 3281–3285). In the rabbit all go to axillary glands more nearly as in man (Figs. 3286 and 3287).

Lymphatic Vessels of the Pelvic Limb.—The ectal lymphatics of the foot, leg, and thigh are almost precisely like those of the hand and arm. The vessels of the toes and sole extend mostly to the dorsum of the foot, and then wind round the leg to the inguinal region, and enter the subcutaneous inguinal lymphatic glands (Figs. 3268 and 3269). A limited number of vessels from the heel and fibular side of the foot accompany the short saphenous vein to the popliteal space where they enter the popliteal glands and join the ental lymphatics.

The subaponeurotic or ental lymphatics also resemble those of the arm, following the main vascular trunks; hence in the crus there are three groups: one on the extensor side of the crus following the anterior tibial vessels, and sometimes traversing one or two anterior tibial glands at about the middle of the crus. The lymphatics penetrate the interosseous ligament near the knee to enter the popliteal glands. The other two groups follow the peroneal and posterior tibial blood-vessels to the popliteal glands. After traversing the popliteal glands the lymphatics follow the femoral vessels to the inguinal region, where they enter the ental inguinal glands and after traversing these accompany the femoral vein and artery into the abdomen to the iliac glands. Besides these there are lymphatic trunks accompanying the sciatic and gluteal vessels, which traverse one or more small glands, gluteal and ischiatic glands, at the sacrosciatic foramen and then enter the hypogastric glands. The trunk following the obturator artery constantly traverses, according to Cruveilhier, a considerable gland (*glandula foraminis obturatorii*) before entering the hypogastric glands.

In the dog, cat, and rabbit there is the same simplicity of the lymphatic trunks as pointed out for the arm. Injections into the pad of the pes (hind



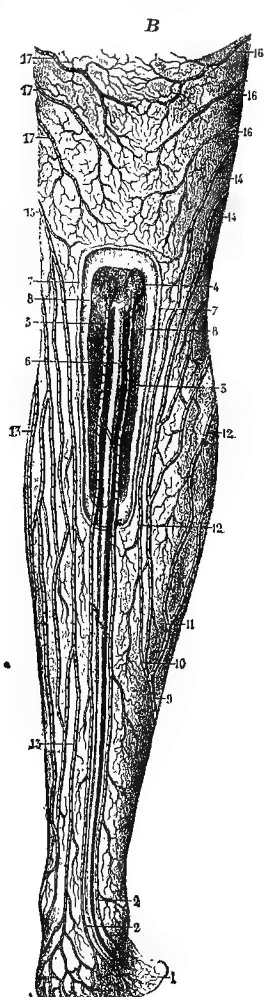


FIG. 3268.

FIG. 3268.—Ectal Lymphatics of the Foot and Leg, to show the Origin, Number, and Course of the Lymphatic Trunks, and the Popliteal and Inguinal Lymphatic Glands. The skin is represented as transparent, except where removed in the popliteal space and in the inguinal region. (Sappey, Atlas.) *A*, The tibial side of the foot and entire leg. 1, 1, Truncules arising from the sole, great toe, and side of the foot; 2, 2, trunks arising at the toes and extending across the dorsum of the foot to reach the tibial side of the leg; 3, great trunk arising from the plantar aspect near the instep, and skirting the tibial or internal malleolus on its way to the inguinal region; 4, 4, 4, trunks coming from the heel and extending along the ankle and leg; 5, 5, and 6, 6, trunks extending along the crus parallel with the calf; 7, 7, 7, 7, trunks winding round the edge of the tibia to reach the tibial or inside of the leg; 8, 8, lymphatic trunks winding round the knee to reach the inside of the leg. They are very tortuous when the knee is extended, more nearly straight when it is flexed; 9, 9, trunks curving round from the extensor side of the meros, or thigh, to reach the inguinal glands; 10, 10, 10, 10, numerous trunks winding round from the flexor side of the thigh to the inguinal glands; 11, 11, 11, trunks curving round from the extensor side of the thigh to the inguinal glands; 12, 12, trunks from the gluteal region; 13, 13, trunks from the perineal and anal region to the inguinal glands; 14, trunks from the scrotum (cf. Fig. 3269); 15, trunk from the penis; 16, the large distal gland of the ectal inguinal group, into which enter so many of the trunks of the leg; 17, another large gland at the same level; 18, large efferent trunk from 16, it follows the course of the femoral artery; 19, lymphatic trunks following the course of the femoral vein; 20, large gland receiving many of the trunks from the extensor sides of the thigh; 21, gland receiving many of the trunks from the flexor side of the thigh; 22, 22, cut end of the vena saphena magna; 23, gland in the groin to which extend many of the lymphatics from the penis (cf. Fig. 3269); 24, large corner gland receiving most of the trunks winding round the ilium from the lumbar and gluteal region; 25, 25, proximal row of glands in the fold of the groin to which extend many of the trunks from the ventral wall of the abdomen; 27, inguinal ring with the contained spermatic cord. *B*, Flexor Aspect of the Distal half of the Leg. 1, 1, Trunks from the heel and fibular side of the foot; 2, 2, two lymphatic trunks following the course of the vena saphena to the popliteal glands; 3 and 5, the two lymphatic trunks, 3 on the fibular, 5 on the tibial side of the vein; 6, vena saphena parva; 7 and 8, cut edge of the skin, and aponeurosis removed to bring the popliteal glands into view; 9, great trunk on the fibular side of the crus; it follows the contour of the calf, and by its branches furnishes nearly all the trunks on the fibular or outside of the crus; 10–12, bifurcations and branches of 9; 13, 13, trunks on the tibial side of the crus. They curve round to the inner side of the leg, and extend to the inguinal glands; 14 and 16, trunks on the fibular side of the thigh, which wind round to the extensor aspect, and then to the inguinal glands (cf. 11 and *A*); 15, large trunks on the tibial or inside of the knee, on its way from the heel, crus, and thigh, to the inguinal glands; 16 and 17, trunks winding round the thigh in opposite directions to reach the inguinal glands.

paw) demonstrate vessels on the dorsum and great-toe side of the foot. Part of these trunks follow the course of the long saphenous vein, others, usually larger trunks, wind round the calf, with the short saphenous vein, to the popliteal space and enter a popliteal gland (Fig. 3281, 16). In the rabbit, branches extend to the popliteal space from both sides of the crus (Fig. 3286). From the popliteal gland the main efferent vessels in all pass between the peroneal and tibial nerves, and accompany the femoral artery and vein, freely anastomosing with the trunk along the saphenous artery. No inguinal glands are present, and the vessels extend directly to the lumbar glands (Fig. 3281, 22).

Lymphatic Glands in the Leg.—The most distal gland is the anterior tibial, situated on the interosseous ligament near the middle of the crus. Through it pass the ental trunks, following the anterior tibial vessels on their way to the popliteal glands. This gland is frequently absent. The popliteal glands (*glandulæ popliteæ*, Fig. 3268) are in the fat in the popliteal space. Two are near the surface and receive the lymphatics accompanying the short saphenous vein. Their efferent trunks pass to the two more deeply situated glands around the popliteal blood-vessels; through the deeper ones pass all the ental vessels of the foot and crus and part of those from the knee. The efferent vessels pass with the femoral blood-vessels to the inguinal glands.

Inguinal glands (*glandulæ lymphaticæ inguinales*, Figs. 3268 and 3269).—There are two layers of these—the ectal or subcutaneous and the ental or subaponeurotic.

The ectal inguinal glands, forming an oblong irregular four-sided figure with one border next Poupart's ligament. The afferent vessels are the ectal lymphatics of the entire leg, the subumbilical part of the body, and the external genitalia. The efferent vessels traverse the cribriform aponeurosis and enter the deep or ental inguinal glands; frequently a few trunks pass into the body cavity and join the iliac glands.

The ental inguinal glands are situated along the femoral artery and vein in the inguinal region and are usually three or four in number, although there may be six or seven. They are covered by the femoral fascia and are in intimate contact with the femoral vessels; one of them is

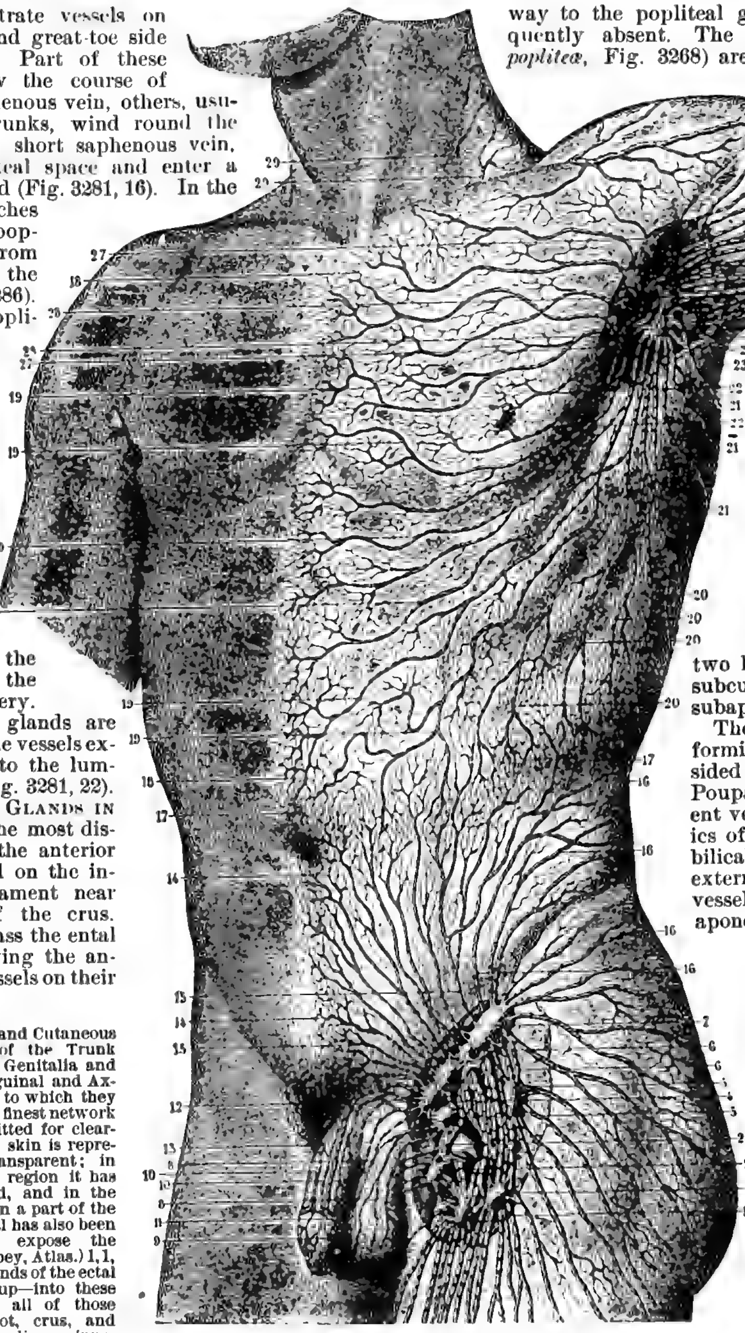


Fig. 3269.—Ectal and Cutaneous Lymphatics of the Trunk and External Genitalia and the Ectal Inguinal and Axillary Glands to which they Extend. The finest network has been omitted for clearness, and the skin is represented as transparent; in the inguinal region it has been removed, and in the axillary region a part of the great pectoral has also been removed to expose the glands. (Sappey, Atlas.) 1, 1, The distal glands of the ectal inguinal group—into these enter nearly all of those from the foot, crus, and thigh; 2, 2, median or inner glands of this group—to these come many of the trunks from the tibial or upper and inner aspect of the thigh; 3, gland near the cut end of the vena saphena magna, which receives most of the lymphatics from the median gluteal, the anal, and the perineal regions, and the scrotum; 4, a large gland forming the proximal and median corner of the ectal inguinal group—it receives the lymphatics from the penis, or, in the female, from the clitoris and part of the labia; 5, the lateral or outer gland of this group, receiving many vessels from the thigh; 6, 6, proximal glands next the abdomen—they receive the lymphatics from the ventral subumbilical region; 7, large gland forming the lateral and proximal angle of the inguinal group—to it extend the trunks from the lumbar, gluteal, and partly, also, from the abdominal region; 8, 8, lymphatics of the scrotum; 9, vessels from the prepuce; 10, 10, vessels from the integument of the penis, extending along the lateral and dorsal aspect of the organ; 11, 11, vessel making a circle around the corona of the glans—ordinarily these unite to form a single dorsal vessel, but here they remain separate and extend in a parallel course to the pubis, where each one turns to the corresponding inguinal gland; 12 and 13, the two trunks from the corona of the glans—when these unite into one they bifurcate opposite the pubis and extend to the two sides as do these independent trunks; 14, 14, subumbilical lymphatics of the abdomen—they interdigitate at the ventrimeson with those from the right side of the body, just as is shown by those extending toward the axilla, so that in this intermediate area an injection might fill the vessels going in both directions, although there might be no true anastomoses of the two groups of vessels; 15, 15, subumbilical lymphatic trunks; 16, 16, trunks arising from the lumbar and gluteal region; 17, 17, area or zone where the subumbilical and thoracic lymphatics interdigitate; 18, 18, area of interdigitating vessels along the ventrimeson; 19, 19, 19, 19, 19, 19, beginnings of the trunks along the ventrimeson; 20, 20, trunks on the lateral aspect of the thorax on their way to the axilla; 21, 21, 21 trunks from the dorsal part of the thorax, on their way to the axillary glands; 22, 22, trunks from the mammary region (cf. Fig. 3274); 23, 23, trunks from the dorsal scapular region; 24, 24, trunks from the arm (cf. Fig. 3267); 25, large trunk from the ectal brachial or supraepitrochlear glands (cf. Fig. 3267); 26, trunk accompanying the cephalic vein and terminating in the subclavian glands (cf. Fig. 3267); 27, cut through the tissues to bring into view the axillary glands; 28, axillary lymphatic glands—only part of them are exposed; 29, 29, vessels from the dorsal and lateral aspects of the neck—they terminate in the supraclavicular glands.

Lymphatic System.

found almost constantly in the mouth of the inner femoral or crural ring, which, according to Henle, it assists in closing. The afferent vessels of this group are derived from the ental lymphatics of the foot, crus, and thigh (in part); the efferent trunks from the popliteal and most of those from the ectal inguinal glands.

A part of the efferent vessels traverse the abdominal wall with the femoral artery, but most of them accompany the femoral vein through the crural canal. They join the iliac glands, sending a few branches, however, to the hypogastric glands.

In the larger domestic animals (horse and ox) the glands of the leg are about as numerous as in man, but with the cat, dog, and rabbit they are represented only by the popliteal gland, the inguinal glands being absent, unless the gland on the external epigastric vessels may represent the ectal inguinal glands. As the iliac glands are also absent, vessels may pass from the foot (*i.e.*, those accompanying the saphenous artery) directly to the lumbar glands (Figs. 3281, 3284, and 3286).

Lymphatics of the Abdomen and External Genitalia.—The ectal lymphatics of the abdomen have three quite sharply defined areas of origin, and from these the vessels extend in opposite directions. The areas are the dorsimeson, the ventrimeson, and a somewhat irregular zone surrounding the body at the level of the umbilicus (Fig. 3269). The vessels cross these boundaries and interdigitate in a complex manner; frequently a puncture made in the boundary will give rise to an injection in both directions, although injections made at either side would inject only the corresponding side. In the lower animals especially investigated for this—cat and opossum—the communication from side to side is more intimate, an injection of one side often filling that of the other. This is especially marked opposite the pubis of the opossum, where there is constantly a large transverse lymphatic, recalling the transverse vessels between the jugular veins.

As seen in Fig. 3269, the lymphatics of the umbilical region of the body extend in the most direct manner on the abdomen to the inguinal or the axillary glands. Those from the lumbar and gluteal regions extend around in great curves, often following the crest of the ilium, to the lateral inguinal glands. Others from the gluteal region curve round the nates to the perineal and anal regions, finally to join the perineal and anal vessels and extend with them to the median glands of the ectal inguinal group.

The lymphatic network around the anal opening is very dense and is continuous with the lymphatics of the rectum. Those of the perineum are less dense. From both these regions the vessels wind round the thigh to the median or inner of the ectal inguinal glands. In the female the number of the trunks from the perineum is reduced apparently in direct proportion to the reduction in area of the region. The lymphatics of the external genitalia of the male are naturally divisible into those of the scrotum and the penis. The vessels of the scrotum are very numerous, perhaps more so than in any other equal area of integument in the body. As in the trunk, the meson—here indicated by the raphe—forms a natural dividing line for the two sides. The vessels extend in great curves, partly to the pubis and partly on the thigh, to enter the median row of ectal inguinal lymphatic glands; those on the thigh communicating with the vessels from the perineum, and those of the pubis with the cutaneous vessels of the penis. The vessels of the integument of the penis, commencing on both surfaces of the prepuce and from the line of the urethra, wind round the two sides to the so-called dorsum of the organ when they extend toward the pubis, and curve laterally toward the two sides to enter the large gland forming the corner of the ectal group (Fig. 3269, 4). The lymphatics of the glans penis are exceedingly numerous, and in several superimposed layers of networks. The collecting trunks converge toward the frænum preputii, where they are joined by the trunks from the urethra.

The urethral lymphatics begin at the prostate, anastomose with the prostatic lymphatics, with the network of the ejaculatory canals, and through them with the *vesiculæ seminales.* They extend to the *meatus urinarius,* forming a hollow cylindrical network of large, densely packed lymphatics (Fig. 3270), which reaches its greatest development opposite the fossa navicularis. Opposite the frænum two or three trunks penetrate the urethral wall and join the trunks from the glans, then penetrate the substance of the penis and reach the dorsal aspect of the *corpus spongiosum,* where the trunks of the two sides usually unite into one, which follows the course of the deep blood-vessels to the pubis, when it again divides, sending a branch to each side, finally to terminate in the large median gland of the ectal inguinal group (Fig. 3269). According to most authors, the urethral and glandular lymphatics of the penis follow the internal pudic blood-vessels into the abdomen and enter the hypogastric glands. But Sappey is very definite, both in his atlas and anatomy, in stating that they enter the large gland forming the corner of the ectal group.[1]

The lymphatics of the external genitalia of the female very closely resemble those of the male in their arrangement and termination. The collecting trunks from the clitoris and the surrounding parts extend nearly directly to the pubis, where they curve to the right and left, and terminate in the large median gland forming the corner of the ectal inguinal group, and, according to Krause,[6] they also communicate with the lymphatics of the round ligament of the uterus.

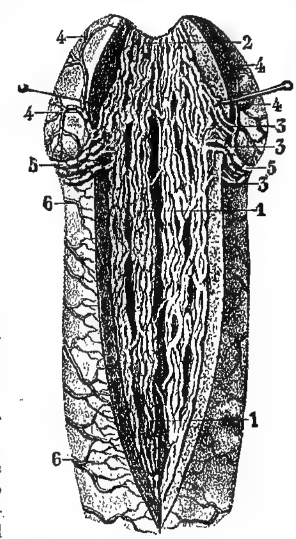


Fig. 3270.—Human Penis, opened Longitudinally to show the Urethral Lymphatics. (Sappey, Atlas.) 1, 1, The very abundant longitudinal network of vessels in the urethral mucosa; 2, continuity of the urethral lymphatics with those of the glans at the meatus urinarius; 3, 3, 3, trunks traversing the urethral wall opposite the frænum and joining those of the glans; 4, 4, 4, 4, trunks from the periphery of the glans joining those from the urethra; 5, 5, large trunks formed by the union of the urethral lymphatics and those from the glans; they penetrate the substance of the penis and follow the deep blood-vessels to the pubis, whence, according to Sappey, they extend to the inguinal, but, according to many authors, to the hypogastric lymphatic glands; 6, 6, lymphatics of the integument of the penis.

The lymphatics of the female urethra are less abundant than in the male. The trunks from the urethra, meatus urinarius, labia, and the external or inferior fourth of the vagina extend laterally to reach the vulvo-crural fold, in which they wind around the thigh, with a few small trunks from the perineum to the median of the ectal inguinal glands, only a few reaching the large corner gland to which so many from the male genitalia extend.

The ental lymphatics of the abdominal wall and the lumbar part of the trunk follow the deep blood-vessels; part, therefore, extend to the sternal and axillary glands; part, with the deep epigastric vessels, to the iliac glands; part, with the lumbar and ileo-lumbar vessels, to the lumbar glands. Still others follow the circumflex iliac vessels, often traversing one or more glands along the crest of the ilium before finally entering the iliac glands.

With the dog, cat, and rabbit, the lymphatics of the abdominal wall and the external genitalia are as in man, except that the tendency to form anastomoses across the meson is more marked, and that there is constantly present along the external epigastric vessels, about opposite the brim of the pelvis, a considerable gland. To this gland pass the ectal abdominal lymphatics, also part of those from the elongated mam-

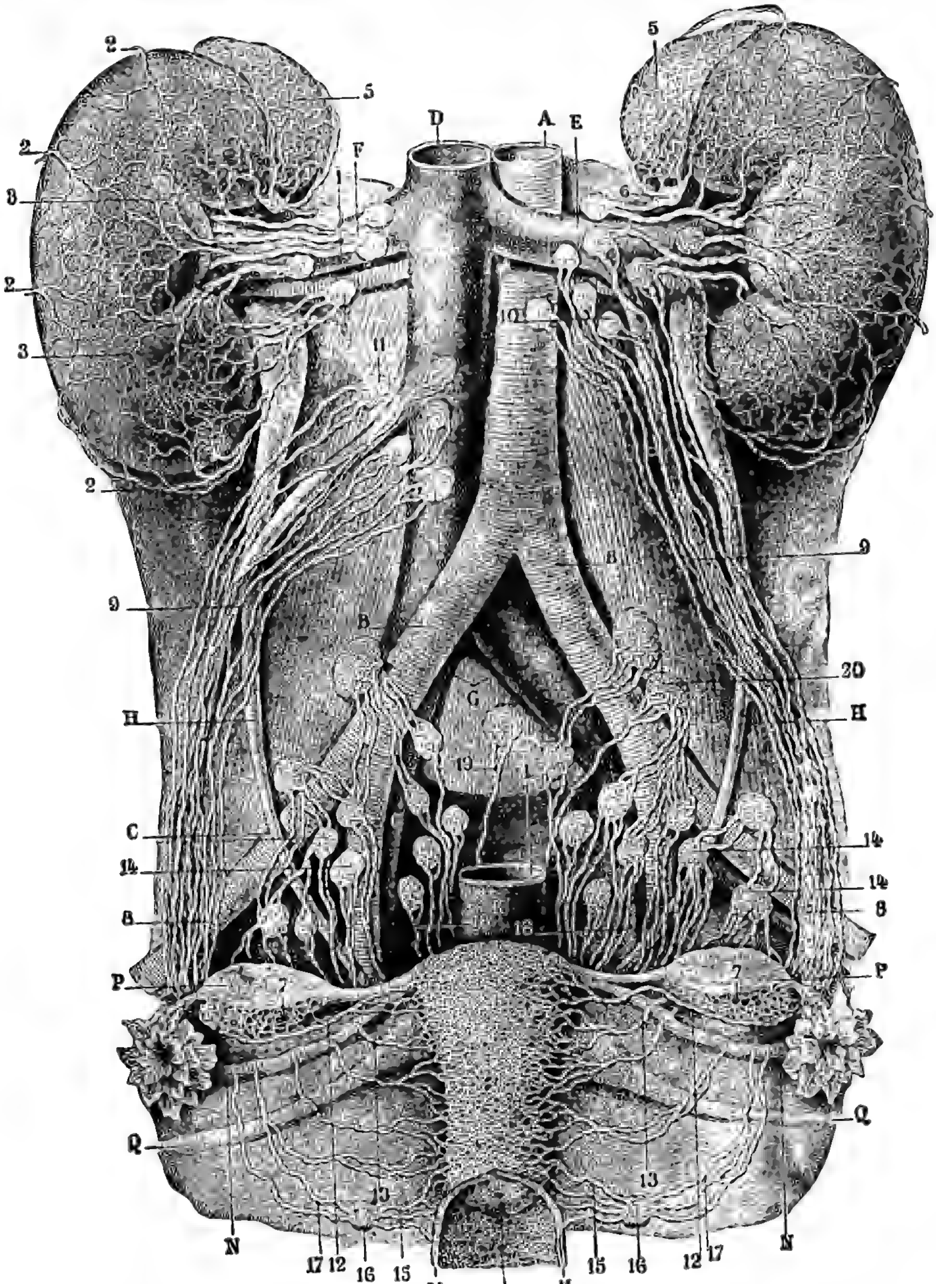


FIG. 3271.—Lymphatics of the Kidneys, Adrenals, and Internal Genitalia of a Girl of Thirteen Years. (Sappey, Atlas.) *A*, abdominal aorta; *B*, *B*, common iliac arteries; *C*, *C*, the external and internal iliac arteries formed by the bifurcation of the common iliac; *D*, post-cava; *E* and *F*, left and right renal veins; *G*, common iliac veins; *H*, *H*, ureters; *I*, cut end of the rectum; *K*, uterus; *L*, neck of the uterus (the line points to the os uteri); *M*, *M*, cut edge of the vaginal wall; *N*, *N*, Fallopian tubes; *P*, *P*, ovaries; *Q*, *Q*, round ligaments. 1, ental lymphatic trunks from the kidney and the glands of the lumbar plexus into which they enter; 2, 2, 2, 2, surface or ectal lymphatics of the kidney which extend first to the lateral aspect, and then converge around the ends of the kidney to the hilus, where they join the ental lymphatics, or enter the same group of glands independently; 3, 3, vessels on the broad surface of the kidney converging directly to the hilus to join the ental lymphatics; 4, gland receiving the ectal lymphatics of the caudal third of the kidney on the right; 5, lymphatic network of the adrenal, it freely anastomoses with that of the kidney, and many of the trunks enter a gland situated in the angle between the adrenal and the kidney on the mesal aspect; 6, lymphatic gland through which pass many of the lymphatics of the adrenal, and some from the kidney; 7, 7, subovarian lymphatic network; it is joined by a large trunk from the base of the uterus, and together they follow the utero-ovarian vein to the lumbar lymphatic plexus; 8 and 9, trunks from the subovarian network to lumbar glands at the termination of the ovarian vein; 10, 10, lumbar glands receiving the left ovarian trunks; part of these are common to the lymphatics of the kidney; 11, 11, glands receiving those from the right; 12, 12, trunks from the base of the uterus to the subovarian network; 13, 13, trunks from the borders and the ventral face of the uterus, they extend to 14, the iliac group of glands; 15, vessels arising from the neck of the uterus, the uterine mucosa, the vaginal part of the uterus, and from about three-fourths of the extent of the vagina; they extend to 16, the utero-vaginal gland; 17, 17, efferent vessels from the utero-vaginal gland to the iliac glands; 18, 18, vessels from the dorsal part of the neck of the uterus, extending to the hypogastric lymphatic glands; 19, trunk from the neck of the uterus to a gland on the body of the fifth lumbar vertebra; its presence is exceptional; 20, iliac gland receiving an unusual trunk from the neck of the uterus.

mary glands and from the external genitalia. There is another gland along the external epigastric blood-vessels about opposite the umbilicus, in the cat at least. After traversing these glands the efferent vessels either join or accompany the femoral lymphatics to the lumbar glands. In the cat they penetrate the abdominal wall with the epigastric artery, and extend, in part, to the hypogastric, and in part to the lumbar glands (Fig. 3281, 14, 21). The epigastric glands may represent the ectal inguinal glands of man. In the rabbit there is also constantly present a gland on the iliolumbar vessels, next the abdominal wall, and along the edges of the sartorius muscle; the efferent vessels pass to the lumbar glands (see 22 of Fig. 3286).

LYMPHATICS OF THE PELVIC AND ABDOMINAL VISCERA.—*Internal genitals of the male—testicle, spermiduct, vesiculæ seminales, and prostate.*—Probably no organ in the masculine body is more richly supplied with lymphatics than the testicle. Those of the albuginea are sometimes described as the ectal lymphatics of the testis.

They are only moderately numerous, and extend upon the spermiduct to join those from the testicle proper. Those of the testicle proper follow the seminal tubules to the epididymis, and joining those of the epididymis extend with the spermatic cord through the inguinal canal. After reaching the body cavity they

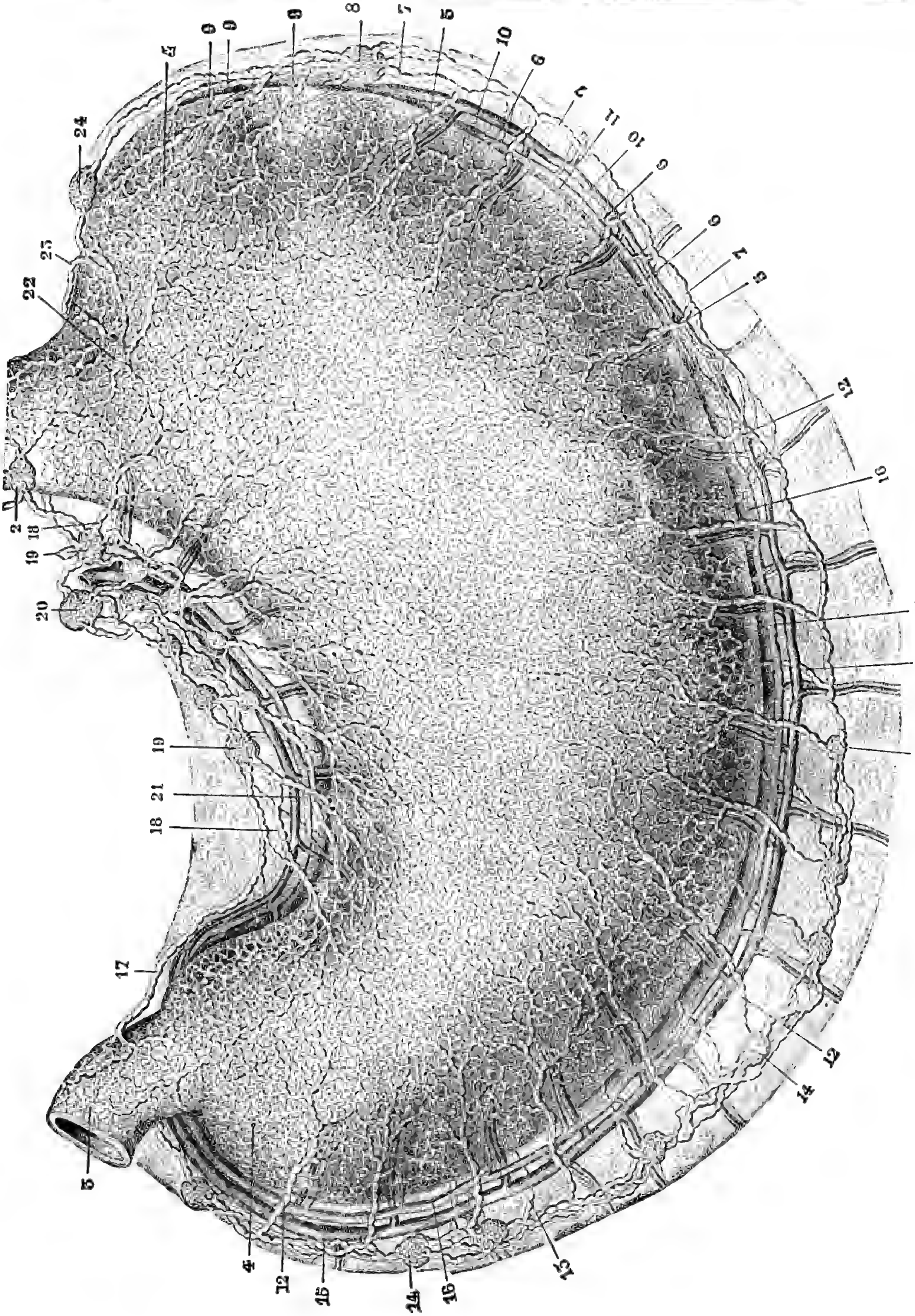
EXPLANATION OF
PLATE XLIII.

EXPLANATION OF PLATE XLIII.

Which Represents the Lymphatics of the Human Stomach. (Sappey, Atlas.)

1, Gastric end of the œsophagus; 2, lymphatic gland receiving part of the œsophageal lymphatics; its efferent vessels extend to the glands around the coronary blood-vessels and there join those from the stomach; 4, 4, fine network of vessels in the muscularis of the stomach; 3, the beginning of the duodenum; 4, 4, fine network of lymphatic vessels in the muscularis; from this fine network arise all the collecting trunks of the muscular coat; 5, 5, 5, lymphatic trunks on the left part of the great curvature; 5, 5, 6, 6, lymphatic vessels from the dorsal and ventral surfaces of the left third of the great curvature; 7, 7, 7, the principal trunk encircling the left half of the great curvature of the stomach; it receives the branches from the stomach and extends toward the left to enter a large gland (8) situated near the tail of the pancreas and the hilus of the spleen; 8, gland at the left of the stomach near the hilus of the spleen; it receives trunks from both directions, also some from the spleen; 9, trunks from the extreme left of the stomach to the gland marked 8; 10, vena gastro-epiploica sinistra; 11, arteria gastro-epiploica sinistra; 12 and 13, trunks from the dorsal and ventral aspect of the pyloric region; 14, 14, 14, the chain of glands on the right along the great curvature; through these pass all the lymphatics from the half next the greater curvature. The efferent trunks from these glands finally extend to the glands at the head of the pancreas; all the glands in the chain around the great curvature are sometimes designated as the *glandulæ lymphaticæ gastro-epiploicæ inferiores*. They lie in the great omentum, and form part of the cœliac lymphatic plexus; 15, 16, vasa gastro-epiploica dextra; 17, trunk from the duodenum and the pylorus to the glands along the lesser curvature; 18, 18, trunks extending to the lesser curvature; 19, 19, the lymphatic glands along the gastric coronary vessels in the lesser curvature (*glandulæ lymphaticæ gastro-epiploicæ superiores*); they receive all the so-called ascending trunks from the stomach and some of the trunks from the œsophagus; they form part of the cœliac lymphatic plexus; 20, the large cœliac gland to which the efferent vessels from 19 extend; 21, vasa coronaria gastrica; 22, gland, often double, on the ventral aspect of the cardia; 23, large trunk winding round the cardia and joining the trunk to 22 and 24; 24, gland, sometimes double, at the extreme left of the great curvature.

PLATE XLIII.



LYMPHATICS OF THE HUMAN STOMACH
(SAPPEY, ATLAS)

follow the blood-vessels, and finally terminate in the lumbar glands near the end of the spermatic vein.

The lymphatics of the testis of a mature animal are exceedingly easy to inject by the puncture method, and the collecting trunks accompanying the spermatic vein are so prominent, straight, and well supplied with valves that they are among the most striking of the lymphatic trunks in the body.

The lymphatics of the spermiduct are abundant at the ends, but very few along the middle part. Those from the testicular half follow the lymphatics of the testis, while those from the other half join the lymphatics of the vesiculæ seminales. The lymphatics of vesiculæ seminales form a close network, which was first described by Hewson; they unite into two principal trunks. Those next the spermiduct join the lymphatics of the latter, and together they enter one of the iliac glands. The other trunk passes between the prostate and vesiculæ seminales, so as to join an iliac gland. The lymphatics of the prostate were discovered and described by Sappey in 1854, who found them abundant, and with two collecting trunks on each side. One of the trunks passes quite directly to one of the hypogastric glands, while the other extends upon the walls of the urocyst, or urinary bladder, and then curves to the side to enter a hypogastric gland. The trunks extending upon the urocyst were mistaken by Mascagni and Cruikshank for the lymphatics from the bladder itself.

Internal Female Genitalia—Vagina, Uterus, Fallopian Tubes, and Ovaries.—As described above, the external or inferior fourth of the vagina sends its lymphatics to the ectal inguinal glands; from the remaining three-fourths the collecting trunks extend toward the uterus, penetrate the walls of the vagina, and traverse the utero-vaginal lymphatic gland on the way to the hypogastric glands. Up to the present, no lymphatics have been demonstrated in the muscular wall of the vagina in the human being, but their presence has been shown in that of the large domestic animals.

The uterine lymphatics are naturally divided into those of the mucosa and those of the muscularis. Those of the mucosa are difficult or impossible to demonstrate in a gravid uterus, and often so in a non-gravid adult uterus, and Sappey states that he never succeeded in demonstrating them in the uterine mucosa of any of the lower animals. It is only in girls before puberty that these lymphatics are demonstrable by the ordinary methods. No doubt they exist in the adult woman, and also in the uterine mucosa of the lower animals, but they have not been satisfactorily demonstrated. When demonstrated in a child they showed a delicate network whose collecting trunks traverse the walls of the neck of the uterus and enter the utero-vaginal lymphatic glands (15 and 16, of Fig. 3271). At the os uteri they are continuous with those on the vaginal part of the uterus and the vaginal mucosa.

The lymphatics of the uterine walls are numerous and easily demonstrated in most animals. The collecting trunks extend laterally in the broad ligament on each side to three different groups of glands; those from the summit follow the Fallopian tubes out to the ovary, where they join the ovarian network, and accompany the collecting trunks of the ovary to the lumbar glands around the termination of the ovarian veins (Fig. 3271). Those from the body of the organ extend across the broad ligament, curve round the Fallopian tubes, and enter the iliac glands; while those from the cervical region extend with those from the utero-vaginal glands to the hypogastric plexus.

Lymphatics have been demonstrated only on the uterine and ovarian ends of the Fallopian tubes. But it is probable that they are present throughout the whole extent. The collecting trunks accompany the ovarian lymphatics.

The lymphatics of the ovary, like those of the testis, are in prodigious numbers, and are very easily injected. The collecting trunks are very long and straight and accompany the ovarian vein, and consequently those on the left are opposite the hilus of the kidney (Fig. 3271).

In the lower animals, so far as has been investigated, the lymphatics of the internal genitalia agree in all essential particulars with those of the human being. In the dog, cat, and rabbit, while the ovarian and testicular lymphatics follow the same general course, they almost always enter the lumbar glands, and therefore do not follow the spermatic or ovarian veins to their termination (Fig. 3281, 21, 22).

Urinary Organs and Adrenal.—Up to the present time all efforts to demonstrate lymphatics in the mucosa of the urocyst or urinary bladder have failed both with men and with animals, but the muscular coat has been shown to be plentifully supplied. The vessels form a wide-meshed network at the summit and on the body. This network unites into one or more trunks on each side, and the trunks extend nearly or quite to the neck when they turn aside and enter the hypogastric lymphatic glands. The trunks described by Cruikshank and Mascagni as urocystic lymphatics were really from the prostate. Sappey succeeded only once in injecting them in man, but almost constantly in the dog and rabbit.

The muscularis of the ureters has been shown to possess lymphatics in the horse, but all attempts to demonstrate them in the mucosa have failed. Although not demonstrated in man they are presumably present.

The lymphatics of the kidney form an ectal network over the surface and an ental network in the substance of the organ. The trunks were first seen in 1532 by Massa, but first described carefully by Nuck in 1590. Those of the surface form a wide-meshed network, the collecting trunks of which extend in part directly toward the hilus of the kidney and join the ental lymphatics and part extend toward the convex border and then wind round the ends to the hilus. Next the adrenal the lymphatics of the two organs are closely connected. The ental lymphatics follow the blood-vessels and terminate in a group of the lumbar glands situated on the renal vessels.

Although the blood-vessels of the adrenal have been long known, the lymphatics were not so early discovered. It is now known that the lymphatics are as abundant as the blood-vessels, extending throughout the substance as well as upon the surface. The collecting trunks, many of them join those of the kidney, and all extend to a gland near the junction of the adrenal and kidney (5, 6, of Fig. 3271).

Lymphatics of the Intestine and Stomach.—Throughout the entire alimentary canal, it has been shown that where a distinct muscular coat exists the lymphatics form two layers or sets, one in the mucosa, including the submucosa, and one in the muscularis. In those parts supported by duplicatures of serosa (mesenteries) the finer network of the mucosa proper extends to a coarse and characteristic network in the submucosa (Fig. 3298), and finally the collecting trunks penetrate the wall at the attached edge and join the lymphatics of the muscularis. The lymphatics of the muscularis are throughout its entire thickness, but soon become subserous and wind round to the attached edge, and with those from the mucosa extend between the layers of the supporting membrane mostly in company with blood-vessels to lymphatic glands, which are also situated between the serosal walls (Fig. 3272, 2, 3, 4; Plate XLIV.).

The intestinal lymphatics at the anus are directly continuous with those of the skin. The trunks from the muscularis and mucosa of the rectum extend between the folds of the mesorectum, often traversing minute glands in their course, and then enter the sacral lymphatic glands and ultimately go to the lumbar glands on their way to the chylocyst. The lymphatics of the main part of the *colon descendens* pass to the lumbar lymphatic plexus. Those of the *cæcum, colon ascendens et transversum,* also part of the *colon descendens* pass through one or more of the numerous mesocolic glands and then enter the mesenteric glands and mingle with the lacteals from

the small intestine, and with these go through the *truncus intestinalis* to the chylocyst.

Lacteals.—The lymphatics of the small intestine are usually called lacteals or chyle vessels, from the fact that during digestion they have a cloudy or milky appearance owing to the contained chyle (Figs. 3292, 3293, 3294, 3300).

As the small intestine has two planes of lymphatics like the rest of the alimentary canal, it is really only those of the mucosa which absorb and convey the chyle, and which, therefore, should properly be denominated lacteals, as those from the muscularis always convey lymph only. A further and finer distinction still has been made by Sappey,[1] who holds that the vessels of the intestinal villi are the only ones which absorb the chyle, and they do nothing else, so that they alone are the true lacteals, and that the other lymph vessels of the mucosa and submucosa, including those from the Peyerian patches and other lymphoid tissue, should be considered simply lymphatics, as they take no part in the absorption of the chyle. The submucosal network simply receives the chyle poured into it by the lacteals of the villi. As stated above, this is not the common view. It is ordinarily believed that the lacteals contain lymph like other lymphatics, except during digestion. It is also common to call all the vessels from the small intestine lacteal vessels, without regard to their origin from the muscularis or the mucosa. Whatever the origin, all the vessels unite at the attached border and extend to the nearest gland, where their contents are mixed, so that usually all the collecting trunks in the mesentery appear milky and are called lacteals or chyle vessels, although some of them might really have come from the large intestine. In man there are usually several tiers of mesenteric glands through which the chyle passes before finally emptying into the large trunk along the superior mesenteric artery. This trunk, which also receives the efferent vessels of the cœliac and mesocolic glands (*truncus lymphaticus intestinalis*), is either single or multiple, and forms one of the most important constituents of the chylocyst (Figs. 3281–3287).

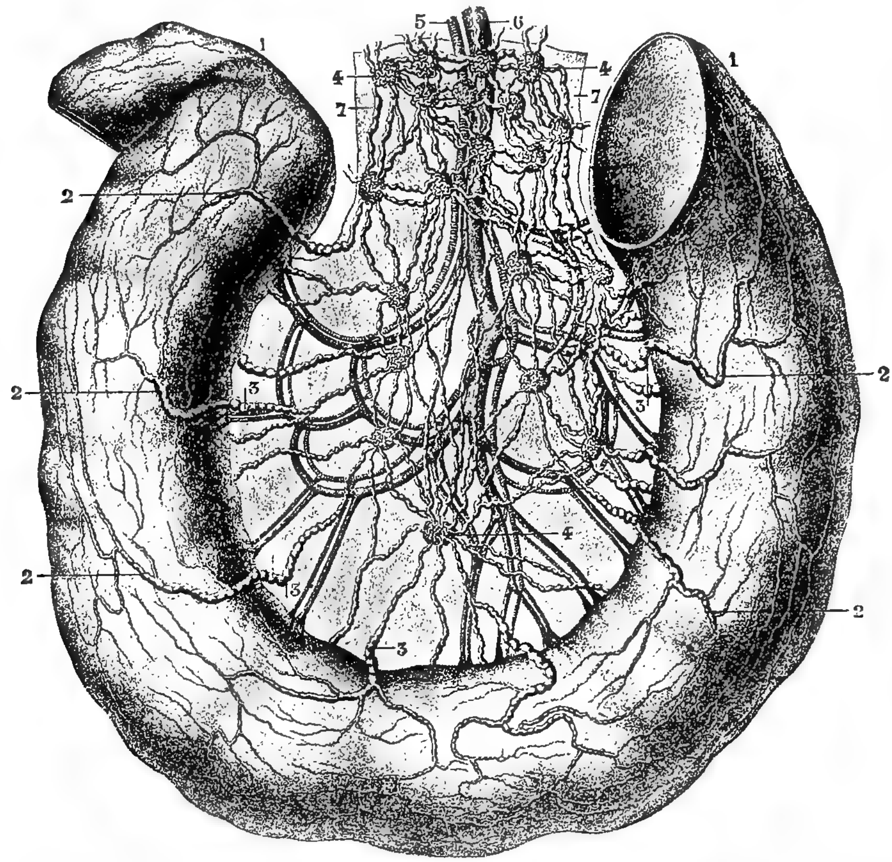


FIG. 3272.—Loop of the Small Intestine of Man, to show the Mesenteric Glands and Blood-vessels, and the Lymphatics from the Muscularis. (Sappey, Atlas.) 1, 1, The ends of the loop of intestine; 2, 2, 2, 2, 2, lymphatic vessels arising in the muscular layer; 3, 3, 3, swellings or enlargements in these vessels near the mesenteric edge of the intestine; 4, 4, 4, mesenteric glands along the course of the lymphatics; 5, branch of the superior mesenteric artery; 6, mesenteric vein; 7, the mesentery.

Stomach.—The lymphatics of the stomach are continuous with those of the œsophagus and duodenum. Those of the muscularis form a most beautiful network throughout the entire thickness of the coat; the collecting trunklets penetrate the tissue and become subserous, and from an intermediate area on both faces extend to the nearest of the chain of lymphatic glands, extending almost around both curvatures; those in the lesser curvature being known as the *glandulæ lymphaticæ gastro-epiploicæ superiores*, and those around the great curvature as the *glandulæ lymphaticæ gastro-epiploicæ inferiores* (Plate XLIII.). The lymphatics of the gastric mucosa form a remarkable network throughout the entire thickness of the coat, being very fine in the mucosa proper and coarser in the submucosa. The collecting vessels penetrate the muscularis along the curvatures, join those of the muscularis, extend to the same glands, and finally to the intestinal lymphatic trunk (Plate XLIV.).

Pancreas.—The lymphatics of this organ are difficult to demonstrate, but when well injected are found to form a fine network around the tubules, and the collecting trunks emerge quite directly to the surface, and form upon the surface a round-meshed, rather coarse network around the lobules. From this network vessels extend in three directions—part of them going to the tail or splenic end of the pancreas to join the glands at the hilus of the spleen, part to the gastric edge of the pancreas to enter some of the numerous glands along the course of the splenic vessels, and still others extend toward the duodenum to enter a large gland which also receives part of the lymphatics of the duodenum. The lymph finally reaches the intestinal trunk after traversing one or more of the cœliac glands. No lymphatics have been demonstrated in the pancreatic ducts.

Spleen.—The lymphatics of the spleen are in enormous numbers. Their origin seems to be from the lymph follicles so abundant throughout the organ. According to Sappey, the usual division of the lymphatics into a superficial and deep set does not hold with man, in whom

EXPLANATION OF
PLATE XLIV.

EXPLANATION OF PLATE XLIV.

Which represents the arteries, veins, and lymphatics of the different layers of the stomach, and the lymphatics of the layers of the small intestine of the dog. (From Franklin P. Mall.)

FIG. 1.—"Reconstruction of a Small Portion of the Middle Zone of the Stomach. The long diameter of the drawing is in the direction of the longitudinal muscle fibres. It was built up from thirty-six drawings, and each drawing is an exact representation of a specimen." Enlarged about 10 times. (*a*) Mucosa; (*b*) muscularis mucosæ; (*c*) submucosa; (*d*) circular muscular layer; (*e*) longitudinal muscular layer. Arteries, red; veins, blue; lymphatics, brown.

As shown in the drawing the arteries and veins form a coarse network in about the middle of the thickness of the submucosa, and from this meshwork branches pass directly through the circular muscular layer on one side and through the muscularis mucosæ on the other. Between the muscular layers another meshwork of vessels is formed, but after passing through the muscularis mucosæ the arteries in the dog extend directly into the mucosa and break up into capillaries between and around the glands. In the cat a network of arteries is formed after traversing the muscularis mucosæ, and from this network twigs pass into the mucosa and break up into capillaries.

The veins form a meshwork near the free surface of the mucosa. From this first meshwork branches pass down to the muscularis mucosæ and there form a somewhat coarser network at the base of the gastric glands. From this mucosal network the vessels penetrate the muscularis mucosæ and accompany the arteries.

The lymphatics begin by blind, branched, finger-like vessels between the gastric glands. These finger-like beginnings unite and form a meshwork between mucosa and muscularis mucosæ.

Another meshwork is formed on the opposite side of the muscularis mucosæ and from that point a coarse network is formed in the submucosa and between the muscular layers. Valves appear in the lymphatics as they penetrate the muscularis mucosæ. The vessels penetrate the walls of the stomach and pass to lymphatic glands along the greater or lesser curvature as shown in Plate XLIII.

FIG. 2.—Segment of the Small Intestine of a Dog to Show the General Distribution of the Lymphatic Vessels. Mucosa and villi, white; muscularis mucosæ, blue-green; submucosa, pink; circular muscular layer, orange; longitudinal muscular layer, yellow; lymphatic vessels, blue. (*Fl*) Lymph follicles in the mucosa (cf. Fig. 3); (*M.L.*) mucosal lymphatic network; (*S.M.L.*) submucosal lymphatic network; (*J–Msl–L*) intermuscular lymphatic network. The efferent lymph vessels from the submucosal and intermuscular networks are shown below at the mesenteric edge of the intestine. From this point they pass to the lymphatic glands (cf. Figs. 3272, 3281–3286).

Some of the villi are represented with the club-shaped central lacteal or lymphatic. It will be noticed also that at the base of the villi there is a lymphatic network, and that in passing from one layer to another of the intestines the vessels pursue a nearly straight course (cf. Fig. 3). The passage through the muscularis mucosæ is indicated by blue dots, thus giving it a sieve or punctate appearance.

FIG. 3.—Section of the Small Intestine of a Dog to Show the Arrangement of the Lymphatics in the Villi and in the Different Layers. Lymphatics, blue; villi, two crypts of Lieberkühn, muscularis mucosæ, a lymph follicle and the longitudinal muscular layer, pink; mucosa and circular muscular layer, white; submucosa and one lymph follicle, gray. One of the villi is shown in an uncontracted condition. The others were strongly retracted by the use of ten-per-cent. nitric acid.

In this figure is well shown the club-shaped central lacteal or lymphatic with a slender, spiral projection extending nearly to the end of the villus (cf. Fig. 3294). In the second villus from the left two central lacteals are shown.

From the network at the base of the villi the vessels extend directly to the mucosal network (Fig. 2, *M.L.*). From this point on they possess valves. Surrounding the lymph follicles is a dense lymph network. The figure shows also that the muscularis mucosæ is not present over the lymph follicles

FIG. 1

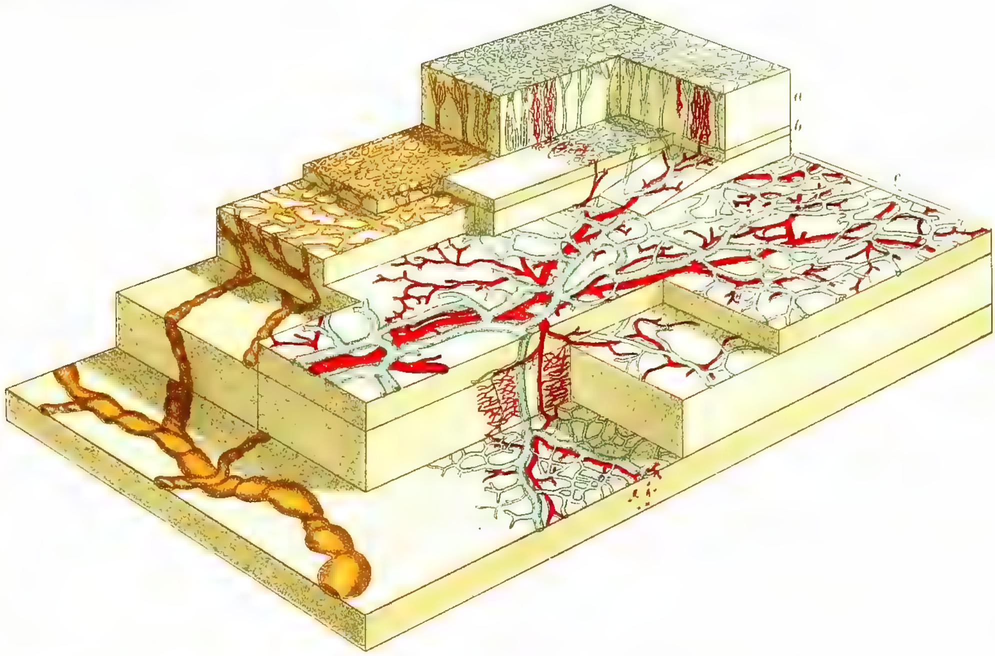


FIG. 2

FIG. 3

Blood Vessels and Lymphatics of the Dog's Stomach and Lymphatics of the Dog's small Intestine

(FROM FRANKLIN P. MALL.)

any vessels on the surface quickly enter the substance of the organ and accompany the ental blood-vessels. With the horse, ox, and pig, however, there is a true ectal network extending over the entire surface. The collecting trunks pass to the hilus of the organ and terminate in the numerous glands there situated. The efferent trunks from these glands pass to the cœliac glands and the intestinal lymphatic trunk, or some may enter the chylocyst directly.

Liver.—The lymphatics of the liver were very early seen, and the efferent trunks *from* the hilus were, for a long time, supposed to be the continuation of the lacteals *to* the liver. It has been found that the lymphatic system of the liver is quite as remarkable as the blood supply. In general there are both ectal and ental lymphatic vessels, and the ducts and gall bladder possess a rich supply. The collecting trunks form three great groups and take three main courses, following the portal or extend to the glands around the postcava as it enters the thorax. On both sides of the suspensory ligament the trunks collect in great numbers, and extend between the folds of the suspensory ligament to the diaphragm, which they penetrate, and enter two or three glands whose efferents join the sternal plexus (14 of Fig. 3275, and 13 of Fig. 3276). Still farther to the left, a group passes round to the postcava as it enters the thorax on the right, still others penetrate the triangular ligament and enter the glands around the œsophagus. Many of the apparently superficial lymphatics of this lobe penetrate the substance of the liver and join the ental lymphatics as with the right lobe. In fact, in most animals this is the normal condition, and a true ectal set of lymphatics is not present. On the concave surface of the liver, many of the surface lymphatics penetrate the liver substance and join the ental lymphatics, but the greater number join the glands in the hilus and thus mingle with

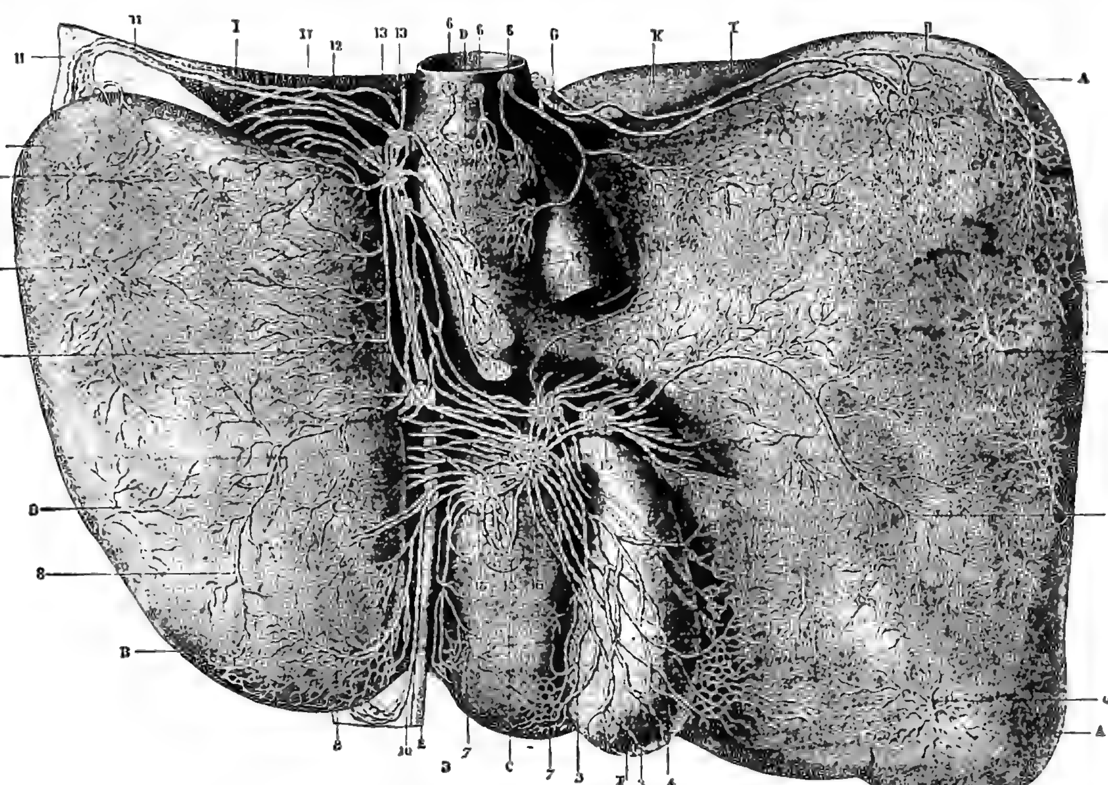


FIG. 3273.—Lympatics and Lymphatic Glands on the Concave Aspect of the Liver of Man. (Sappey, Atlas.) *A*, *A*, Right lobe of the liver; *B*, *B*, left lobe; *C*, quadrate lobe; *D*, Spigelian lobe; *E*, round ligament or remnant of umbilical vein; *F*, cholecyst or gall bladder; *G*, postcava receiving the hepatic veins just as it traverses the diaphragm; *H*, left triangular ligament of the liver; *I*, diaphragm; *K*, the most projecting part of the convex surface of the liver. 1, 1, Two trunks near the cephalic edge of the right lobe extending to the glands on the postcava just within the thorax; 2, single trunk from the middle of the right lobe to the lymphatic glands in the hilus of the liver by the neck of the cholecyst; 3, 3, trunks upon and at the border of the cholecyst to the glands in the hilus; 4, two vessels having the same origin and termination, but covered by the cholecyst; their course is indicated by the dotted lines; 5, 5, trunks arising on the surface of the right lobe, but penetrating the substance of the liver to accompany the ental vessels; all the vessels from the surface take this course in most animals; 6, 6, 6, trunks from the Spigelian lobe, and the glands around the postcava receiving them; 7, 7, vessels belonging to the quadrate lobe; 8, 8, principal trunks of the left lobe; 9, 9, vessels arising on the surface, but soon entering the liver to join the deep lymphatics like 5 of the right lobe; 10, trunks from the convex surface of the liver following the round ligament and finally entering the glands at the hilus; 11, 11, 12, several trunks from the convex surface of the left lobe, winding over to the concave surface and entering glands in the fissure of the ductus venosus; 13, 13, lymphatic glands in the fissure of the ductus venosus, their efferent vessels extend to the glands in the hilus; 14, glands corresponding to the terminal end of the œsophagus; 15, 15, lymphatic glands receiving the lymphatics from most of the concave surface of the liver and the ental lymphatics following the portal vein.

vessels to the hilus, the hepatic vessels to the postcava, and the supensory ligament to the diaphragm.

The ectal or superficial lymphatics of the convex surface extend in four directions, according to their position. Most of those near the caudal or inferior border penetrate the surface and join the ental lymphatics. In the right cephalic (superior) part, they wind round the border and join the glands at the head of the pancreas, the ental lymphatics (Fig. 3273). The ental or deep lymphatics, according to Sappey, are divided into two distinct, although anastomosing sets, one set following the portal vessels and bile-ducts, the other the hepatic vessels. Those following the hepatic vessels enter the thorax, traversing some glands on the postcava, and mingling with the ectal lymphatics, follow the pillars of the diaphragm to join the thoracic duct. The lymphat-

ics following the portal veins reach the hilus of the liver, and traverse one or more of the glands there situated (Fig. 3273). From these glands in the hilus, branches extend to the glands in the lesser curvature of

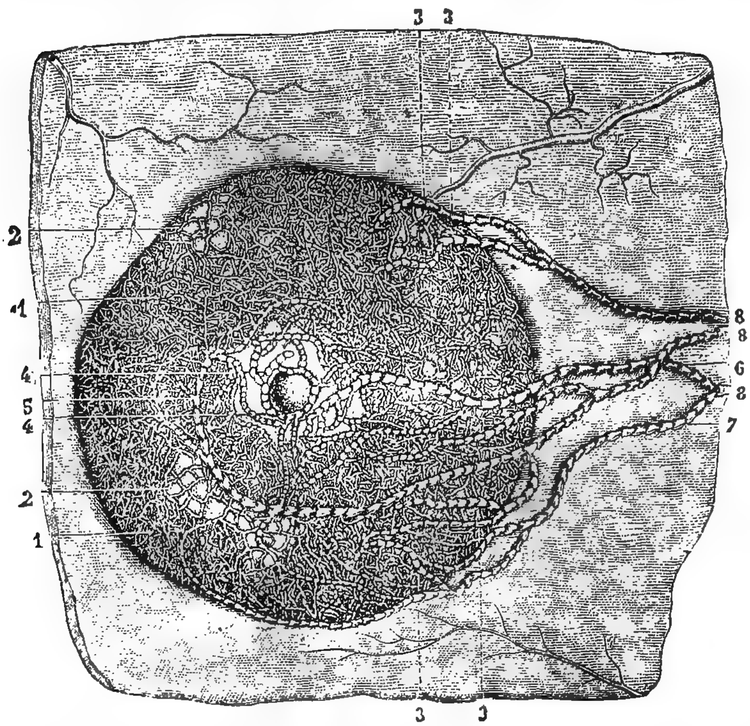


FIG. 3274.—Left Mammary Gland of a Woman during Lactation. The skin and adipose tissue have been removed to bring the lymphatics plainly into view. At three of the corners of the figure blood-vessels are represented. (Sappey, Atlas and Anat.) 1, 1, Network of lymphatics so dense that they make almost a continuous layer. The entire gland is filled throughout in this way; 2, 2, truncules surrounding the lobules, the finer network being omitted; 3, 3, 3, large trunks at the border of the gland; 4, 4, network of large vessels around the nipple; they originate in the depth of the mamma; 5, 5, great trunk arising at the mesal side of the nipple, and extending across the gland and pectoral region to the axillary lymphatic glands; 6, large trunk from the lateral aspect of the nipple extending directly toward the axilla; 7, large trunk from the caudal (inferior) border of the mamma, and uniting with the preceding on its way to the axilla; 8, 8, the two great trunks from the mammary gland going to terminate in the axillary lymphatic glands.

the stomach, and to those on the splenic vessels; but finally all pass to the cœliac glands, and then some branches may enter the chylocyst independently, but most of them join the intestinal trunk.

LYMPHATIC GLANDS, PLEXUSES, AND TRUNKS OF THE ABDOMINAL AND PELVIC CAVITIES.—The glands in the abdominal and pelvic cavities form a continuous network from the inguinal glands to those in the œsophageal opening; they also extend out on the great vessels of the viscera. Although there are no sharply defined limits and limited grouping of the two hundred to four hundred glands in this part of the body, groups have been made as in the neck for convenience. Following Krause, the following groups may be recognized, commencing with the iliac region: (1) Iliac; (2) hypogastric; (3) sacral; (4) lumbar; (5) mesenteric, including those of the mesocolon; (6) cœliac. Each of these groups of glands with the connecting vessels is also called a plexus. As the efferent vessels of all these groups unite to form the *chylocyst* and thoracic duct by three main trunks, these also have received names: (1, 2) The two lumbar trunks (a *truncus lymphaticus lumbalis* of each side) from the iliac, hypogastric, sacral, and lumbar plexuses, and (3) a single trunk (*truncus lymphaticus intestinalis*) from the mesenteric and cœliac lymphatic plexuses. As was remarked in discussing the cervical glands, different authors may assign a collecting trunk from an organ to different groups of glands, although the same gland is meant. As the division into groups is artificial, and the glands vary considerably in position and in different individuals, even in number, this confusion is probably inevitable.

The iliac lymphatic glands and plexus (*glandulæ iliacæ, s. iliacæ, s. anteriores; plexus lymphaticus iliacus, s. iliacus externus, s. anterior*) form a chain along the external and common iliac blood-vessels. At the crural ring this plexus is continuous with the inguinal plexus. The afferent vessels are from the inguinal plexus, those accompanying the internal epigastric and circumflex iliac blood-vessels, those from the vesiculæ seminales and the body of the uterus (those from the last two sources are often said to extend to the hypogastric plexus). This plexus is connected with the hypogastric and sacral by several communicating branches, but the main efferent trunks pass to the lumbar plexus.

Hypogastric Glands and Plexus (*glandulæ lymphaticæ hypogastricæ, s. iliacæ internæ, s. pelvinæ; plexus hypogastricus, s. iliacus internus, s. pelvinus*). These are on the sides of the pelvis, around the hypogastric and internal iliac blood-vessels. The afferent lymphatics are from the gluteal, sciatic, and obturator vessels, part of the spermiduct, the prostate, urocyst, most of the vagina, the uterine mucosa, and neck of the uterus. According to most authors, the ental lymphatics of the external genitalia in both sexes pass to these glands. Sometimes also part of the inguinal efferents pass to this group. This plexus is closely connected with the iliac and sacral, but its principal efferent trunks pass to the lumbar plexus.

Sacral Glands and Plexus (*glandulæ lymphaticæ sacrales; plexus lymphaticus sacralis*). This group of glands is between the folds of the mesorectum next the sacrum. The afferent vessels come from a part of the pelvic wall, and the vertebral canal, and from the rectum. Like the other pelvic plexuses it is connected with all the others, but its efferent trunks pass to the lumbar plexus.

The Lumbar Glands and Plexus (*glandulæ lymphaticæ lumbales, s. lumbares; plexus lymphaticus lumbalis*). The lumbar glands form three irregular rows, one mesal and two lateral, extending along the great blood-vessels from the bifurcation of the aorta nearly to the origin of the superior mesenteric artery. Its afferent vessels are the efferent trunks from the iliac, hypogastric, and sacral plexuses, lymphatics accompanying the ilio-lumbar and part of the lumbar blood-vessels, those from the testis, spermiduct in part, ovary, summit of uterus, Fallopian tubes, kidney, adrenal, and most of the colon descendens. It is also connected by a greater or less number of communicating branches with the cœliac plexus. Its efferent vessels unite to form two principal trunks, a right and left lumbar lymphatic trunk (*truncus lymphaticus lumbalis*), which with the intestinal trunk form the *chylocyst*, the enlarged beginning of the thoracic duct.

Cœliac Glands and Plexus (*glandulæ lymphaticæ cœliacæ; plexus lymphaticus cœliacus*). The cœliac plexus is situated along the cœliac vessels, the portal vein and the beginning of the superior mesenteric artery on the dorsal side of the pancreas, duodenum, and pylorus. This group was formerly reckoned as part of the lumbar plexus. The efferent lymphatics come from the stomach,

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part of the œsophagus and duodenum, part of the liver, the pancreas, and spleen. The efferent vessels join the intestinal trunk, or sometimes one or more branches pass directly to the chylocyst.

Mesenteric Glands and Plexus (*glandulæ mesentericæ, s. mesaraicæ, plexus lymphaticus mesentericus, s. mesaraicus*). The mesenteric glands and plexus (one hundred to two hundred) lie along the blood-vessels between the folds of the mesentery and the meso-colon. They are usually in three irregular tiers, one tier being near the intestine, one near the middle, and one near the root of the mesentery. The afferent vessels are from the small intestine, except part of the duodenum, and the large intestine to the sigmoid flexure. The efferent vessels receive the efferent trunks from the cœliac plexus, and then terminate in the chylocyst as the intestinal trunk (*truncus lymphaticus intestinalis*).

As will be seen by a glance at Figs. 3281–3286, the lymphatics and the glands in the abdominal cavity of the dog, cat, and rabbit are essentially as in man, but there is a great concentration of the glands, so that the groups are well defined. No sacral glands were certainly found in any of them.*

LYMPHATICS OF THE THORAX.—The thoracic lymphatics are divisible into three fairly distinct, although communicating, groups: (1) Those of the skin and other surface structures; (2) the ental lymphatics of the thoracic walls, including the diaphragm; (3) the lymphatics of the thoracic viscera—heart, lungs, trachea, and œsophagus.

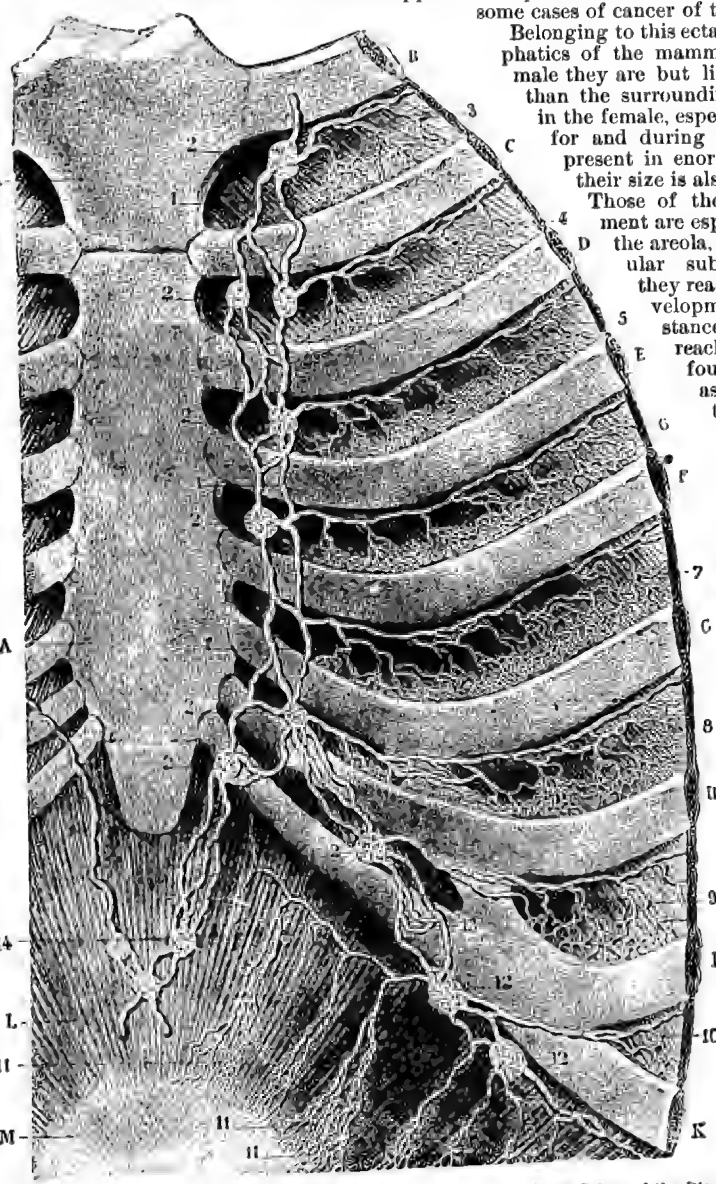

FIG. 3275.—The Ental or Pleural Aspect of the Sternum, Parts of the Ribs and the Diaphragm, to show the Sternal Plexus. (Sappey, Atlas.) *A, A*, Sternum; *B* to *K*, the first nine ribs; *L, M*, the ventral part of the Diaphragm, part of the central tendon being shown at *M*; 1, 1, 1, 1, 2, 2, 2, the sternal plexus of lymphatic glands and the connecting vessels; 3 to 10, lymphatic network and trunks in the intercostal spaces. The trunks extend along the caudal margin of the ribs to reach the sternal glands. These trunks are directly continuous dorsad with the intercostal plexus (cf. Fig. 3280); 11, 11, vessels on the pleural surface of the diaphragm, finally extending to the sternal glands; 12, 12, 13, sternal glands opposite the eighth and ninth ribs and their efferent trunks; 14, glands receiving the lymphatics from the suspensory ligament of the liver.

The ectal lymphatics, like those of the abdomen, are quite sharply divided into those of the right and those of the left side, although on both the dorsi- and ventri-meson the vessels interdigitate.

The beginning of many of the subcutaneous trunks of the thorax is likewise from an oblique zone surrounding the body at about the level of the umbilicus (Fig. 3269), and there is a somewhat similar, although less clearly defined, limiting zone between the neck and thorax. The collecting trunks extend in the most direct manner to the axillary lymphatic glands (Fig. 3269). Part of those, however, in the subclavicular and adjoining pectoral regions pass to the supraclavicular glands. This is supposed to explain the involvement of these glands in some cases of cancer of the breast.[1]

Belonging to this ectal group are the lymphatics of the mammary gland. In the male they are but little more developed than the surrounding integument; but in the female, especially in preparation for and during lactation, they are present in enormous numbers, and their size is also greatly increased. Those of the mammary integument are especially numerous in the areola, but it is in the glandular substance itself that they reach their highest development. From the substance of the gland they reach the surface in four places, and extend as four principal trunks toward the axilla, but most often unite to form two large trunks before entering the axillary glands. Most authors assign part of the lymphatics of the breast to the internal mammary or sternal plexus, but Sappey states that the course is as described above.

Besides the lymphatics from the mammary glands, many of those from the ectal muscles pass to the axillary glands. These trunks pass along the great pectoral muscles and the vasa thoracica longa, and usually traverse a few small glands (pectoral glands) in their course.

The lymphatics of the diaphragm were discovered by Rudbeck, and fully described by Nuck. They are among the most easily demonstrated of any in the body, and from the thinness of the diaphragm and the clearness with which the lymphatics may be fol-

* Sappey describes and figures in his Atlas[1] (Plate XLVIII., Fig. III.) the lumbar trunks in the rabbit and the trunks from the ovary entering them without traversing any glands. He says further concerning the lumbar trunks, in describing the figure: "Gros troncs lymphatiques provenant des membres postérieurs et du bassin; ils se rendent directement dans l'origine du canal thoracique sans avoir traversé dans leur trajet aucun ganglion [lymphatique]." Such a condition was never observed by the writer in any of the white rabbits dissected.

lowed, this organ is a favorite object for study. The lymphatics extend from the peritoneal to the pleural surface, hence it is upon the thoracic face that the great trunks are found (Fig. 3276). These are arranged into three paired and one azygos group. The lymphatic trunks of the diaphragm practically surround the whole organ and the openings through it. From the ventral group, occupying somewhat more than the ventral half, the trunks extend toward the sternum, traverse a gland about opposite the seventh rib, and then extend to the sternal plexus, those of the right going to the right lymphatic trunk, and those of the left going to the thoracic duct (Fig. 3276). The azygos group appears opposite the xiphisternum, and is represented by three glands (supraxiphoid of Sappey, anterior mediastinal of authors), and their efferent trunks. These are not properly diaphragmatic lymphatics, for they come from the surface of the liver and suspensory

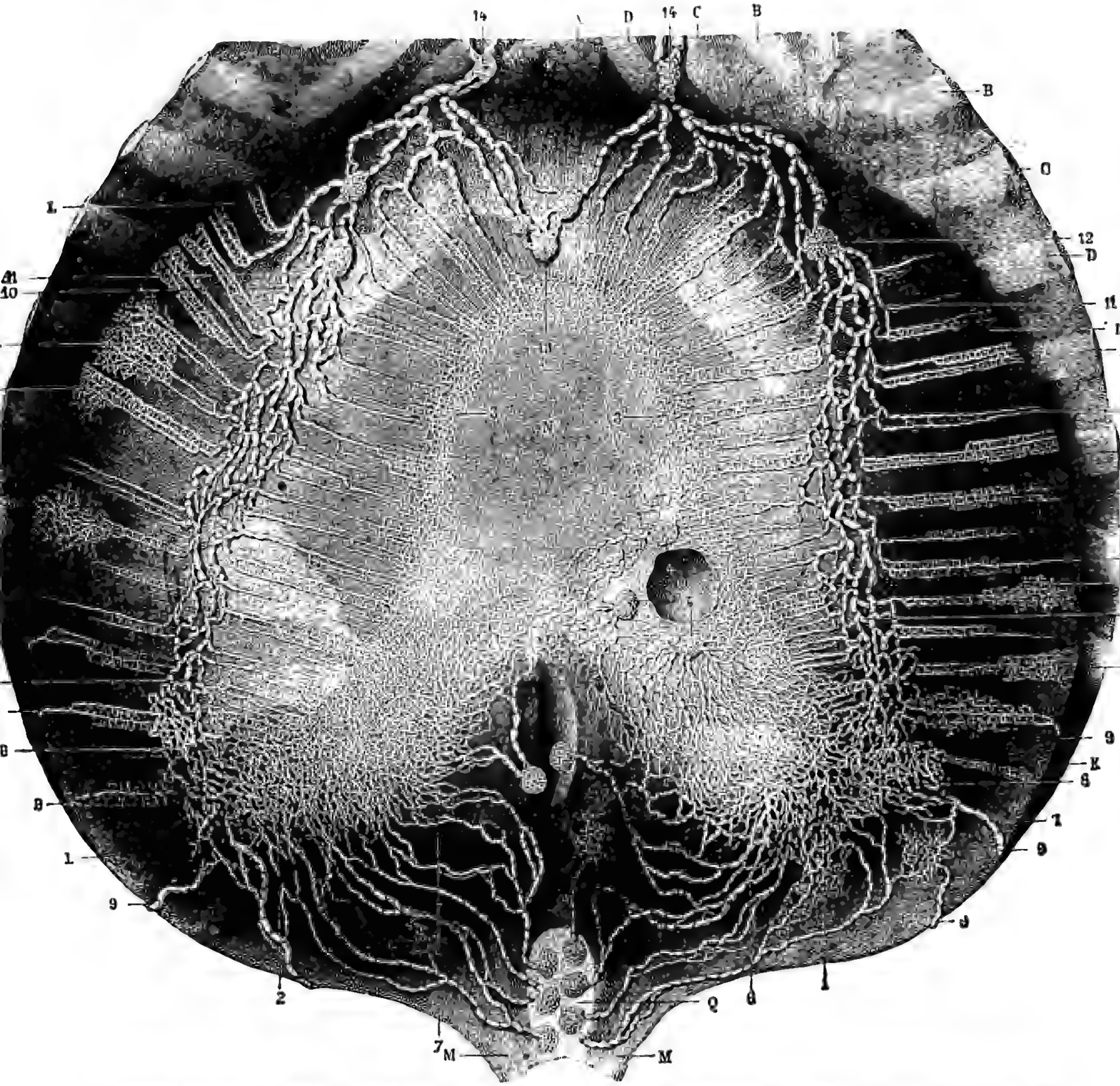

FIG. 3276.—The Lymphatic Vessels and Glands on the Pleural or Thoracic Aspect of the Human Diaphragm. (Sappey, Atlas.) *A*, Xiphisternum; *B*, *C*, *D*, *E*, *F*, *G*, *H*, *K*, 5, 6, 7, 8, 9, 10, 11, and 12, ribs; *L*, *L*, muscular part of the diaphragm next the ribs; *M*, *M*, pillars of the diaphragm; *N*, the three parts of the central tendon of the diaphragm; *O*, passage for the postcava; *P*, œsophageal orifice; *Q*, hiatus aorticus between the two pillars of the diaphragm. The glands in the opening are in the abdomen and belong to the cœliac lymphatic plexus. 1 and 2, The network in the right and left dorsal points of the central tendon; 3, 3, network around the border of the ventral or mesal part of the central tendon; 4, 4, 4, glands around the postcaval opening for the reception of part of the lymphatics of the Central tendon; 5, 5, two glands at the œsophageal opening, they receive the neighboring lymphatics; 6, 7, trunks coming from the dorsal part of the central tendon along the pillars of the diaphragm to enter the glands in the aortic opening at (*Q*); 8, 8, 8, fine lymphatic network of the muscular part of the diaphragm; 9, 9, 9, 9, lymphatic trunks winding around the edge of the diaphragm to enter the cœliac lymphatic glands; 10 and 11, truncules and trunks extending toward the sternal plexus; 12, lymphatic gland on the diaphragm near its ventral attachment opposite the seventh rib; it is double on the left side; 13, three lymphatic glands ventrad of the pericardium, and usually buried in fat. To them extend the lymphatics from the suspensory ligament of the liver; 14, 14, glands of the sternal plexus receiving the efferent vessels from 12 and 13 (cf. Fig. 3275).

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ligament (see Liver). The efferent trunks join the sternal plexus.

From the dorsal part of the diaphragm the trunks converge to the aortic or œsophageal opening (dorsal group), and enter the glands there situated. Other trunks wind round the pillars of the diaphragm and enter the abdomen. As part of the glands in the aortic, and also in the œsophageal opening, are in the abdomen, it follows that part of the lymphatics starting on the peritoneal or abdominal side of the diaphragm extend to the pleural or thoracic side, and then turn back through these trunks into the abdomen before finally terminating in the thoracic duct.

The deep structures of the thoracic walls are drained by lymphatics following the intercostal spaces. As will be seen by consulting Figs. 3275 and 3280, the collecting trunks form a half-circle, the vessels extending both toward the sternal and toward the intercostal plexus. In their course along the intercostal spaces they usually traverse one or more glands. Near the spinal column is a row of glands whose efferent trunks may extend directly to the thoracic duct, but usually two or three of them unite to form a common trunk, which opens into the thoracic duct. It is a remarkable fact that those from the last three intercostal spaces unite to form trunks on each side, which extend through the diaphragm into the abdomen to join the chylocyst, instead of entering the thoracic duct in the thorax (cf. Fig. 3280, where vessels pass from the abdomen to the thorax).

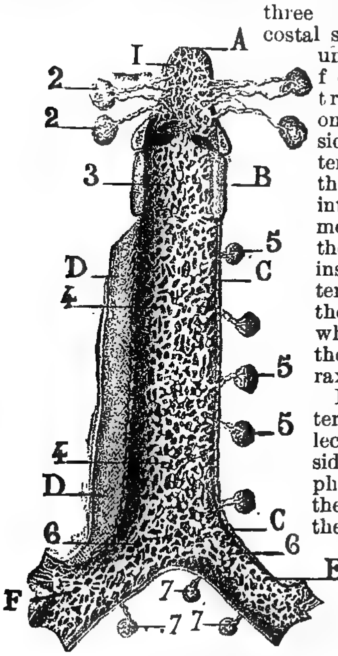


FIG. 3277.—Trachea and Bronchi Opened on the Dorsal Side to Show the Abundant Lymphatic Network of the Mucosa; from a Child at Birth. (Sappey, Atlas.) *A*, epiglottis; *B*, section of the cricoid cartilage to expose the interior of the larynx; *C*, *C*, trachea; *D*, *D*, the membranous portion of the trachea drawn to the left, exposing the interior; *E* and *F*, the two bronchi. 1, The lymphatic network of the epiglottis; 2, 2, ental cervical lymphatic glands (cf. Plate XLII., 13); subglottic network in the larynx; this is very sparing in the adult; 4, 4, network of the tracheal mucosa; 5, 5, ental cervical glands along the trachea into which the collecting trunks enter; 6, 6, the lymphatic network in the bronchi; it will be seen from this figure that the lymphatic network from the epiglottis into the bronchi is uninterruptedly dense; in the adult there are comparatively few lymphatics in the larynx proper and in the trachea; 7, 7, bronchial lymphatic glands.

From the first few intercostal spaces the collecting trunks on the right side pass to the right lymphatic trunk; and from the sternal half of all of the spaces the collecting trunks join the sternal plexus, those on the right extending therefrom to the right lymphatic trunk, and those on the left to the thoracic duct. This offers a very striking illustration of the close connection between the right and left lymphatic trunks in man, a condition much more fully realized in many of the lower animals. The lymphatics of the spinal canal and the muscles of the back follow their blood-vessels and enter the intercostal plexus, the greater number finally reaching the thoracic duct.

Œsophagus.—The lymphatics of the œsophagus are in

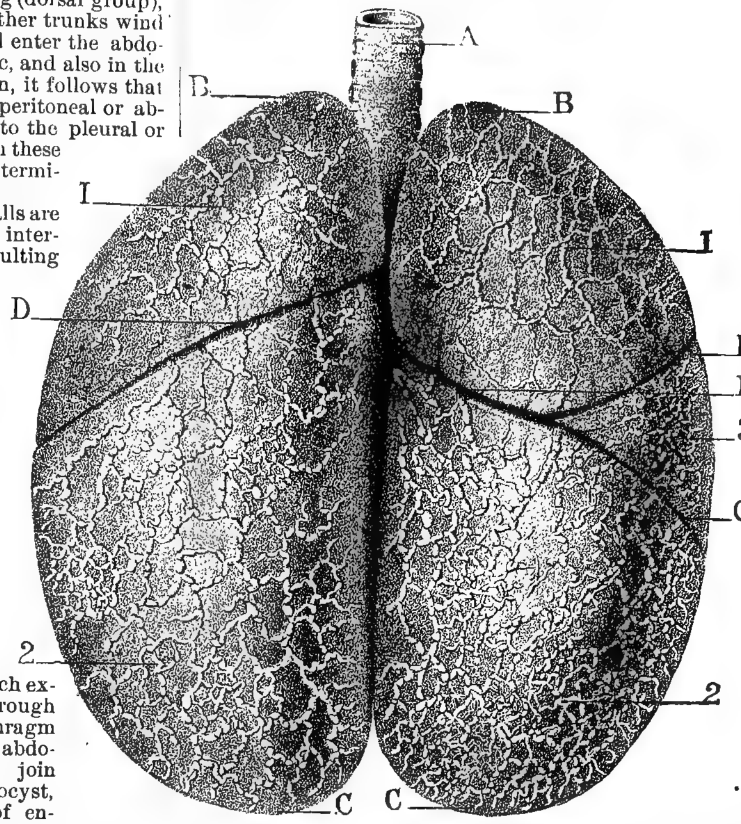


FIG. 3278.—Ectal or Subserous Lymphatics of the Dorsal Surface of the Lungs of a Child at Birth. (Sappey, Atlas.) *A*, trachea—the line points to the membranous portion; *B*, *B*, summit or cephalic lobes of the two lungs; *D*, the fissure dividing the left lung into two lobes; *E*, *F*, *G*, fissures dividing the right lung into three lobes. 1, Lymphatic network on the cephalic lobe; 2, 2, network on the caudal lobe; network on the middle lobe of the right lung. The fine network surrounding and covering the pulmonary lobules is not shown in this figure.

two sets, as in the rest of the alimentary canal, viz., those of the muscularis and those of the mucosa; they penetrate the muscular wall and enter the small glands scattered along its course. The lymphatics are directly continuous with those of the pharynx at one end and with those of the stomach at the other. At the gastric end the collecting trunks, after reaching the surface, extend toward the stomach, and part of them traverse the œsophageal opening and enter the glands around the cardia of the stomach (Plate XLIII.). Those of the middle region enter the dorsal (posterior) mediastinal glands, while those in the neck join the internal jugular plexus. Up to the present time the lymphatics of the muscularis have been actually demonstrated only in the larger domestic animals (horse and ox), but the probability is very strong, that they exist in the human œsophageal muscularis.

Heart.—The cardiac lymphatics are in two groups—a subpericardial and a subendocardial network—but in both cases they are derived from the muscular substance, and not from the serosa. The ectal or subpericardial network commences with the apex of the heart and extends over the whole surface, but the larger trunks occupy the dorsal and ventral grooves or depressions containing the large cardiac blood-vessels. The ental or subendocardial vessels unite into collecting trunks which penetrate the myocardium near the apex and near the auriculo-ventricular groove, and anastomose with the

ectal lymphatics, and all together extend to the groove between the auricles and ventricles, and form an anastomosing circle around the base of the ventricles. The rather few lymphatics of the auricles mostly extend tow-

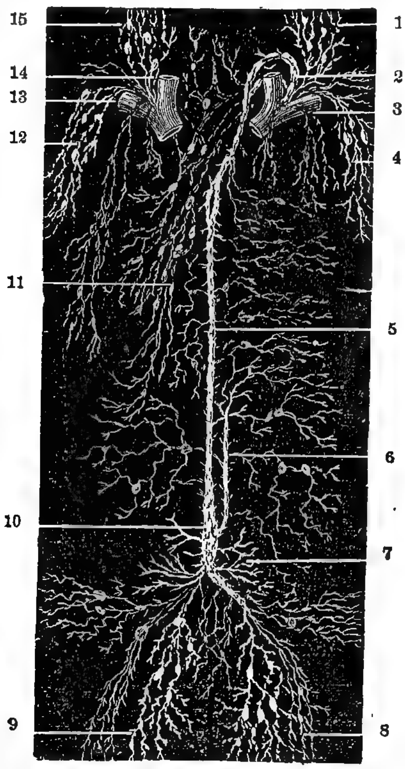


Fig. 3279.—Diagram of the Thoracic Duct, the Right Lymphatic Trunk, and the Lymphatic Plexuses of the Human Body. (After Quain.) 1, Left jugular plexus; 2, arch of the thoracic duct near its entrance into the angle between the subclavian and internal jugular veins; 3, left subclavian vein; 4, left axillary lymphatic plexus; 5, the thoracic duct in the thorax; 6, trunk from the intercostal plexus to the abdomen where it joins the chylocyst; there should be a similar trunk on the left (cf. Fig. 3280); 7, lacteals; 8 and 9, inguinal and iliac plexuses on the left and right; 10, chylocyst or chyle receptacle; 11, the sternal, bronchial, and mediastinal plexuses; 12, axillary plexus on the right; 13 and 14, right subclavian and internal jugular veins; the right lymphatic trunk enters the vein at the angle between the subclavian and internal jugular, as does the thoracic duct on the left; 15, right jugular lymphatic plexus.

ard the auriculo-ventricular groove and join the anastomosing ring, but some extend directly to the main trunks along the two sides of the pulmonary artery. From the anastomosing ring in the auriculo-ventricular groove two trunks arise, the one representing the left heart extends along the left side of the pulmonary artery, and between it and the left auricle to the left bronchial glands, and therefore finally to the thoracic duct. The trunk representing the right heart follows the right side of the pulmonary artery, and passes between this vessel and the arch of the aorta to reach the right bronchial glands, ultimately to terminate in the right common lymphatic trunk.

Lungs.—The lymphatics of the lungs are exceedingly numerous. They arise in the lung substance between the alveoli, and in the bronchial mucosa. Those near the surface extend toward the periphery and become subserous, and then extend to the root of the lung to enter the bronchial glands (Figs. 3277 and 3278). The ental lymphatics follow the bronchi and finally, after traversing a few small glands on the bronchi (the so-called pulmonary lymphatic glands), they enter the bronchial glands. From these glands extend trunks to the left to enter the thoracic duct, and to the right to enter the right common lymphatic trunk.

Trachea and Bronchi.—As seen above, the epiglottis and entire laryngeal opening possess an almost infinite number of lymphatics (Plate XLII.). In the infant this wealth of vessels continues throughout the entire larynx, and trachea and its branches; but as age advances the lymphatics of the larynx, commencing at the level of the vocal cords, and the trachea become less and less, until in the adult they are comparatively few; but in the smaller bronchi the abundant lymphatic network persists. The vessels arise in the mucosa and the intercartilaginous tissue, penetrate the tracheal wall, and are distributed to the glands so abundantly supplied to the neck along the trachea and bronchi (Fig. 3287).

Thoracic Lymphatic Glands.—The lymphatic glands of the thorax are only second in importance and number to those in the abdomen. Within the thorax they form a continuous network, and are closely connected with those of the abdomen on the one hand, and with those of the neck on the other. Those without the cavity are continuous with the axillary glands.

The pectoral glands (*glandulæ lymphaticæ pectorales, s. thoracicæ superficiales*) are situated along the caudal (inferior) border of the great pectoral muscle, and some more deeply along the vasa thoracica longa. Through them pass many of the trunks following the long thoracic blood-vessels, and many of those from the thoracic region on their way to the axillary lymphatic glands.

Within the thorax there are several named groups with corresponding plexuses. The sternal glands and plexus (*glandulæ lymphaticæ sternales, s. substernales, s. thoracicæ profundæ, s. mammariæ, s. presternales; plexus lymphaticus sternalis, s. mammarius internus*) commence opposite the xiphisternum and extend along the thorax on each side of the sternum in company with the sternal blood-vessels (Fig. 3275). The afferent vessels of this plexus come from the deep abdominal muscles in the supra-umbilical region of the abdomen, the ventral two-thirds of the diaphragm, part of the convex surface of the liver through the suprahyoid glands, the structures in the intercostal spaces in the ventral part of the body. The afferent vessels usually join the ventral (anterior) mediastinal glands, and with their trunks pass to the two great common lymph-trunks. Sometimes one or more, or all, of the trunks pass directly to the great lymph-trunks without traversing the mediastinal glands.

The intercostal glands and plexus (*glandulæ lymphaticæ intercostales; plexus lymphaticus intercostalis*) are found on each side of the thorax, in the intercostal spaces, and along the vertebral column. The afferent vessels are from the intercostal structures, the spinal canal, and the deep muscles of the back. The efferent trunks pass mostly to the thoracic duct, but part of those on the right pass to the right lymphatic trunk.

The dorsal or posterior mediastinal glands and plexus (*glandulæ lymphaticæ mediastinales dorsales, s. posteriores; plexus lymphaticus mediastinalis dorsalis, s. posterior*) are situated along the thoracic aorta and the œsophagus, in the dorsal or posterior mediastinal folds. The afferent vessels are from the œsophagus, the dorsal third of the diaphragm, and some from the liver. The efferent vessels enter the thoracic duct, directly, or join the bronchial glands.

The ventral (anterior) mediastinal glands and plexus (*glandulæ lymphaticæ mediastinales ventrales, s. anteriores, s. gl. l. cardiacæ; plexus lymphaticus mediastinalis ventralis, s. anterior*) are in the ventral mediastinal fold, and are principally concentrated around the arch of the aorta and the roots of the great blood-vessels. The glands called supra-xiphoid by Sappey (14 of Fig. 3275) are frequently assigned to this group. The afferent vessels are from the sternal plexus, and through this many vessels from the convex surface of the liver; the lymphatics of the thymus, and, according to some authors, the lymphatics of the heart. The efferent vessels either go to the bronchial glands or join the vessels from these, and extend from the right half to the right lymphatic trunk, and from the left half to the thoracic duct.

The bronchial glands and plexus (*glandulæ lymphaticæ*

bronchiales ; plexus lymphaticus bronchalis) are situated in the bifurcation of the trachea, and extend upon the trachea (where they are called tracheal lymphatic glands) to the internal jugular plexus, and others extend out along the bronchi into the lungs (pulmonary lymphatic glands). In childhood and youth they are pink, but with advancing age they become dark and even black, if the individual has inhaled a plentiful supply of coal dust or other carbonaceous matter. These glands are very large and important. The afferent vessels are from the lungs, and, according to some authors, the heart, the bronchi, the efferent vessels of the dorsal mediastinal glands, and sometimes the ventral mediastinal glands also. The efferent vessels extend from the left side to the thoracic duct, and from the right to the right lymphatic trunk. Frequently the efferent vessels of the sternal, ventral, mediastinal, and bronchial glands unite to form a large single or multiple trunk (*truncus lymphaticus bronchomediastinalis s. bronchomediastinus, s. bronchomediastinicus*), which extends to the common lymphatic trunk of the right or left. Such a trunk is more common on the right. On the left the efferent trunks are usually smaller and less concentrated.

Common Lymphatic Trunks.—In man and the mammals there are but two common lymphatic trunks, one on the right and one on the left side; and these trunks terminate at two points in the great veins of the neck, usually at the junction of the jugular and subclavian veins—that is, just before the formation of the brachiocephalic venous trunks, or in animals like the rabbit (Fig. 3287) with a right and left precava, just before the formation of these. In man and the higher animals these trunks are of different length and size, and receive the lymphatics of very unequal portions of the body, that on the left side being normally much the more extensive In the lowest mammals the tendency is very strong to equalize these trunks, and also the area drained by them: and in the animals below mammals, the two are approximately equal.

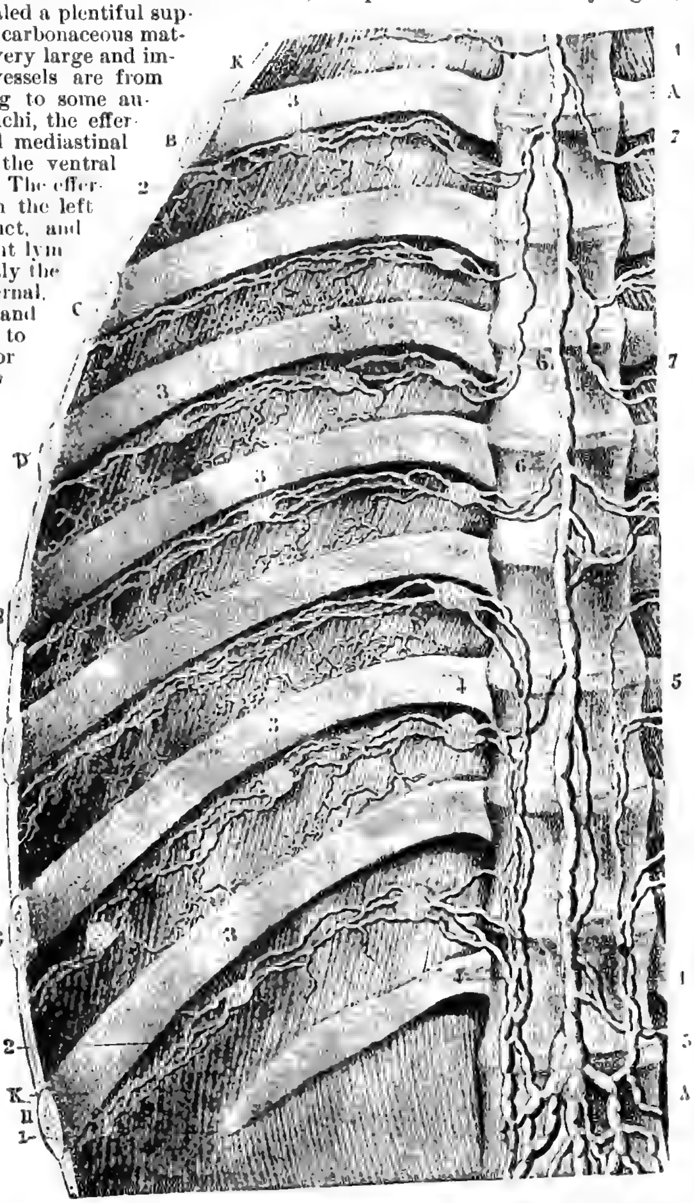


FIG. 3280.—Part of the Thoracic Duct and Intercostal Lymphatics. (Sappey, Atlas.) *B, C, D, E, F, G, H, I, A*, vertebral column opposite the first lumbar vertebra: fifth to the twelfth ribs inclusive; *K*, ectal intercostal muscles between the ribs; the ental or internal intercostals have been removed to show the intercostal lymphatic plexus; 1, the thoracic duct near the chylocyst; it extends along the vertebral column nearly on the meson; 2, 2, trunks arising in the intercostal spaces; 3, 3, 3, lymphatic glands in the course of the vessels; 4, 4, large trunk conveying the lymph from the three or four intercostal spaces into the abdomen and then pouring it into the chylocyst; 5, 5, similar trunk on the left side; 6, 6, and 7, trunks on the right and left, from the intercostal spaces to the thoracic duct.

Thoracic Duct (*chyloductus, ductus thoracicus, s. truncus, s. canalis lymphaticus communis sinister, s. major, s. ductus chyliferus, s. lumbothoracicus ; vena alba thoracis* [Eustachius, 1564]).—The common lymphatic duct, canal, or trunk of the left side collects and empties into the venous system, the lymph of the pelvic limbs, the reproductive and urinary organs, the alimentary canal, pancreas, spleen, much of that of the liver, of the left half of the body cephalad of (above) the umbilicus and a part of that from the right half of the thoracic wall (Figs. 3279 to 3287).

In man the thoracic duct is formed in the abdomen opposite the first, second, or third lumbar vertebra by the union of the trunks of the lumbar and mesenteric lymphatic plexuses. The caudal end is formed by the union of the right and left lumbar trunk (*truncus lymphaticus lumbalis dexter et sinister*). The large trunk thus formed is then increased by the addition of the unpaired or azygous trunk (*truncus intestinalis*) from the stomach and intestines, part of the liver, the spleen and pancreas, and the right and left trunk from the intercostal plexuses (Fig. 3279). At the beginning of the duct where all these confluents unite there is usually a marked dilatation, the chylocyst, chyle receptacle, or cistern of Pecquet (*chylocystis, s. receptaculum chyli, s. cisterna chyli*). This is sometimes absent in man as the confluents form a kind of network instead of one large trunk. In this case the thoracic duct is formed by the union of the network without there being present a special enlargement or chylocyst. This condition is said by Owen to be normal in the marsupials examined by him, but in the dog, cat, rabbit, and most of the higher animals there is usually a very well-marked chylocyst. From the chylocyst the thoracic duct traverses the diaphragm with the aorta, usually on the

right side, and extends along the thorax mostly on the right and dorsal side of the aorta until opposite the sixth to the third thoracic vertebra it gradually inclines to the left, passes dorsad of the arch of the aorta, reaches the left side of the œsophagus which it follows for a short distance, passing on with it along the dorsal side of the great blood-vessels until opposite the seventh cervical vertebra when it forms an arch something like the arch of the aorta, curving ventrad and to the left between the vertebral blood-vessels and the jugular vein to terminate at the junction of the left internal jugular and the subclavian vein. The opening is guarded by a double valve, so that reversal of the direction of the stream is avoided.

The thoracic duct differs in length with the length of the trunk. The average in an adult is about 40 cm., and its diameter is about 2 to 3 mm., it being greater near its origin than near its termination. It in many cases divides into two or more parallel and anastomosing vessels, which finally unite to enter the vein together. The chylocyst is from 40 to 50 mm. long and 6 to 8 mm. in diameter, and in the arch near the termination there is sometimes, if not regularly, found a dilatation something like that shown in the dog and the rabbit (Figs. 3285 and 3287). The thoracic duct receives confluent branches throughout its entire course, and near the termination enter the important trunks from the arm, lungs, and head and neck (the jugular, subclavian, and broncho-mediastinal trunks). The entrance of each of these vessels is usually guarded by a paired valve.

Varieties.—There are sometimes two ducts — one opening into the right, and one into the left veins of the neck. Sometimes a single duct divides, sending one branch to the right and one to the left, as shown in the figure of the cat and rabbit (Figs. 3282 and 3287). Rarely there is a transposition, the left thoracic duct opening on the right. "In two instances the thoracic duct has been seen to terminate in the vena azygos." Multiple openings into the veins are not uncommon (cf. Fig. 3283).

Right common lymphatic trunk (*truncus lymphaticus communis dexter, s. minor ; vena*

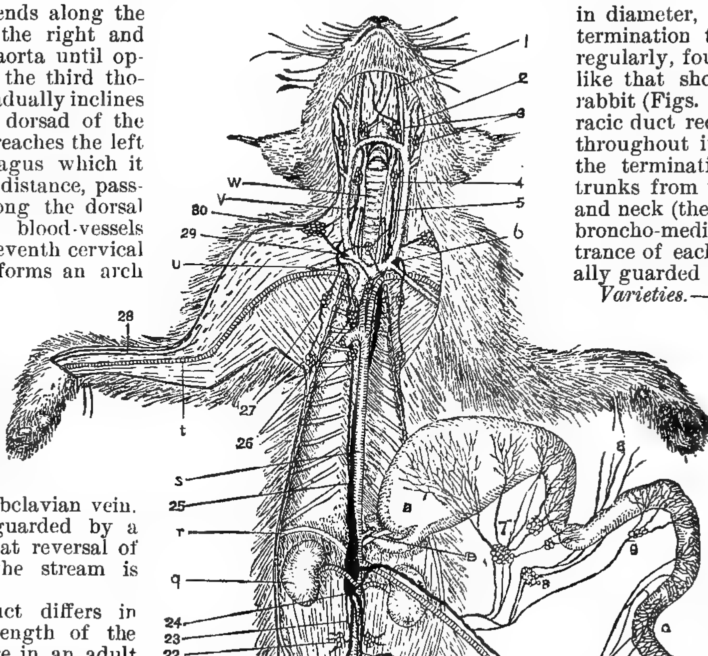
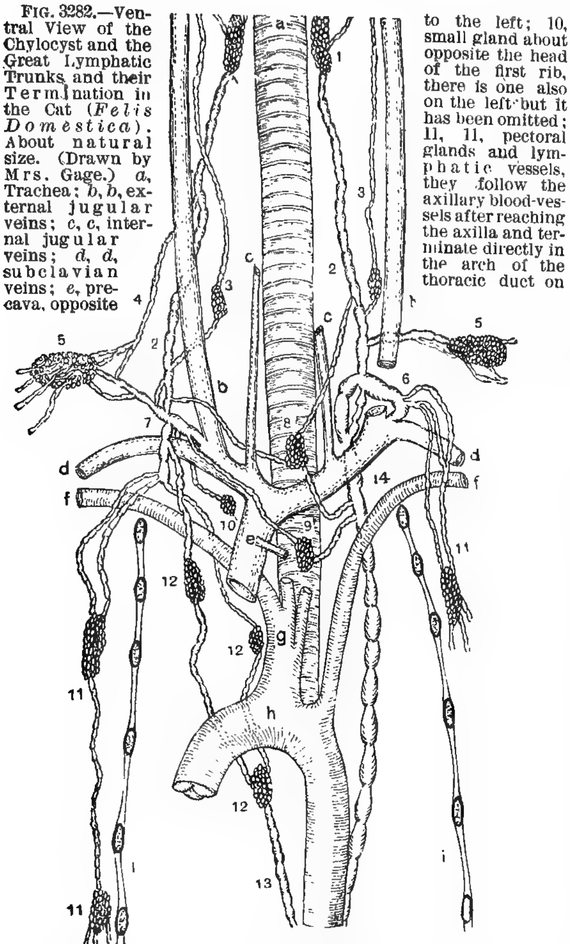


FIG. 3281.—General View of the Lymphatic System of the Cat. (*Felis Domestica.*) (Drawn by Mrs. Gage.) *a*, Stomach; *b*, small intestine; *c*, cæcum; *d*, large intestine; *e*, cœliac axis; *f*, superior mesenteric artery; *g*, inferior mesenteric artery; *h*, external epigastric artery reflected from the abdominal wall upon the thigh; *i*, sciatic nerve dividing into the peroneus and tibialis; *k*, saphenous or internal cutaneous artery; *m*, *n*, femoral artery; *o*, cut edge of the abdominal wall; *p*, ilio-lumbar artery; *q*, right kidney; *r*, cut edge of the diaphragm; *s*, thoracic aorta; *t*, brachial artery, extending into the antibrachium as the radial artery; *u*, subclavian vein; *v*, external jugular vein; *w*, trachea. 1, Lymphatics from the ventral lip and floor of the mouth to the two submaxillary lymphatic glands. As shown in the figure, these trunks cross to the opposite side from which they arose; 2, trunks from the facial region injected from the bare spot on the snout and dorsal lip; 3, the two submaxillary lymphatic glands, one on each side of the facial vein; 4, single ental cervical gland on the side of the trachea and next the carotid artery; into this enter most of the efferent trunks from the submaxillary lymphatic glands; 5, *truncus lymphaticus jugularis* from the ental cervical glands to the thoracic duct on the left, and the right common lymphatic trunk on the right; 6, termination of the thoracic duct at the junction of the subclavian and external jugular veins; 7, lymphatics from the stomach to the cœliac glands; 8, lymphatics from the liver to a cœliac gland; 9, gland near the duodenum into which many of the duodenal lymphatics enter; 10, the two enormous mesenteric glands near the cæcum, often called the glands or pancreas of Asellius, into which most of the lymphatics of the small intestine, cæcum, and part of the colon empty. From these glands extends the great *truncus lymphaticus intestinalis* to the chylocyst, receiving the trunks from the duodenum, liver, and stomach on its way; in the cat, as shown in the figure, the truncus intestinalis is very long and usually single, making it very easy to insert a cannula for a starch or plaster injection; 11, trunks and glands in the cæcal region; 12, lymphatics from the colon, there are usually several small glands near the attachment of the mesentery; 13, glands in the mesocolon around the inferior mesenteric blood-vessels; 14, hypogastric lymphatic glands; 15, gland at the side of the external epigastric blood-vessels. It receives the lymphatics from the abdominal wall, part of the mammary gland and the external genitalia, its efferent vessels go partly to the hypogastric and partly to the lumbar lymphatic glands; the gland has been reflected from the abdominal wall with the external epigastric artery to the muscles of the thigh, it may represent the ectal inguinal group of man; 16, popliteal gland in a mass of fat in the popliteal space. It receives most of the lymphatics of the foot and crus, and sends its efferent trunks between the two great branches of the sciatic nerve to follow the femoral artery; 17, trunks from the dorsum of the foot, winding round the fibular side of the crus with the external saphenous vein across the calf of the leg to the popliteal gland, part of the course is indicated by broken lines; 18, lymphatic trunk from the dorsum and tibial side of the foot following the saphenous or internal cutaneous artery, about opposite to the middle of the thigh it anastomoses freely with those following the femoral vessels; 19, lymphatic trunks accompanying the femoral blood-vessels and finally entering the lumbar glands, no inguinal glands being present; 20, lymphatic trunk accompanying the ilio-lumbar blood-vessels and entering the lumbar lymphatic glands; 21, lumbar lymphatic glands; 22, lumbar glands into which pass the lymphatic trunks from the internal genitalia, these are frequently merged with the preceding; 23, *truncus lymphaticus lumbalis*, there is one on each side, but frequently the trunks are multiple, and the branches of the two sides anastomose, they form principal constituents of the chylocyst; 24, chylocyst formed by the junction of the intestinal and lumbar trunks; 25, thoracic duct, a small branch is indicated as going to the right side of the body; 26, lymphatic glands in the thorax, near the arch of the aorta and bronchi; 27, pectoral lymphatic glands in course of the long thoracic blood-vessels; 28, lymphatics from the dorsum of the manus following the radial nerve and cephalic vein, and finally terminating in the prescapular gland. The course in the brachium, where not visible in this view, is indicated by broken lines, occasionally one or more branches turn at the elbow to follow the brachial vessels into the axilla; in this case they enter the pectoral gland opposite the third rib, true axillary glands appearing to be absent; 29, termination of the right common lymphatic trunk at the junction of the subclavian and external jugular vein; 30, prescapular gland receiving the lymphatics of the arm and shoulder, and usually an anastomosing branch from the jugular trunk, its efferent vessels join the jugular trunk.



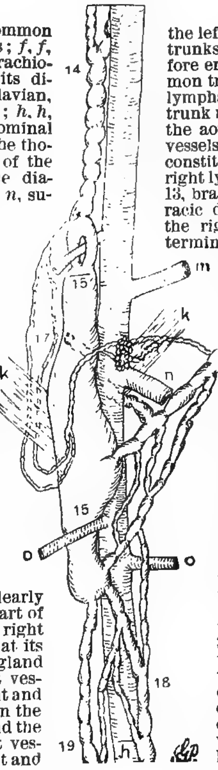
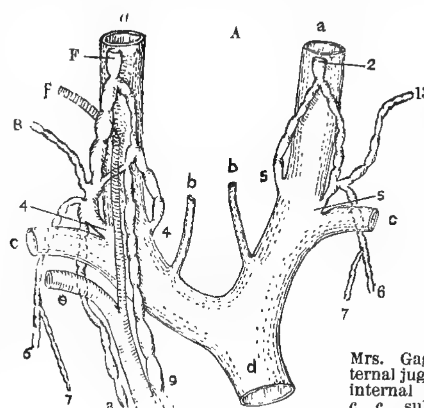


Fig. 3282.—Ventral View of the Chylocyst and the Great Lymphatic Trunks and their Termination in the Cat (*Felis Domestica*). About natural size. (Drawn by Mrs. Gage.) *a*, Trachea; *b*, *b*, external jugular veins; *c*, *c*, internal jugular veins; *d*, *d*, subclavian veins; *e*, precava, opposite the entrance of the common trunk of the sternal veins; *f*, *f*, subclavian arteries; *g*, brachiocephalic artery opposite its division into the right subclavian, the right and left carotids; *h*, *h*, arch of the aorta and abdominal aorta; *i*, *i*, cut edges of the thoracic walls and the ends of the ribs; *k*, *k*, pillars of the diaphragm; *m*, cœliac axis: *n*, superior mesenteric artery; *o*, *o*, the renal arteries. 1, Ental cervical gland; 2, *truncus lymphaticus jugularis*; 3, 3, trunk and gland along the external jugular vein, the trunk is one of the efferent vessels from the lateral of the two submaxillary lymphatic glands (cf. Fig. 3281); 4, anastomosing branches between the jugular trunk and the efferents from the prescapular gland; 5, 5, the right and left prescapular gland; 6, termination of the thoracic duct in the veins at the angle of the subclavian and external jugular, a short segment has been removed from the external jugular to show more clearly the arch of the terminal part of the thoracic duct: 7, the right common lymphatic trunk at its termination; 8, lymphatic gland on the trachea, its efferent vessels extend both to the right and to the left; 9, large gland in the ventral mediastinum around the sternal vessels, its efferent vessels extend both to the right and to the left; 10, small gland about opposite the head of the first rib, there is one also on the left but it has been omitted; 11, 11, pectoral glands and lymphatic vessels, they follow the axillary blood-vessels after reaching the axilla and terminate directly in the arch of the thoracic duct on the left, but join other trunks on the right before entering the common trunk; 12, 12, 12, lymphatic glands and trunk near the arch of the aorta, the efferent vessels form prominent constituents of the right lymphatic trunk; 13, branch of the thoracic duct turning to the right and finally terminating in the right lymphatic trunk; 14, 14, thoracic duct. As indicated by the constrictions the valves are considerably farther apart in the cephalic half; 15, 15, chylocyst on the right side of the aorta and extending for a considerable distance into the thorax; 16, *truncus intestinalis*, the common trunk from the stomach, liver, and intestines (cf. Fig. 3281). Before terminating in the chylocyst it divides into several branches, one of which winds round the left side of the aorta, one sends a branch to a small gland near the origin of the superior mesenteric artery and from this gland the efferent trunk passes laterad of the pillar of the diaphragm, enters the thorax with the splanchnic nerves and terminates in the thoracic duct just beyond the chylocyst; still another branch anastomoses with the lumbar trunks; the lymphatics form a perfect maze in this region, so that it is no wonder Eustachius was bewildered in his first investigation of them; 17, lymphatic vessels from the abdomen to enter the thoracic duct in the thorax; this seems like an exact reversal of the condition in man where some of the lymphatics of the thorax (intercostal plexus) enter the abdomen to assist in forming the chylocyst (cf. Fig. 3280); 18, left and 19, right anastomosing trunks from the lumbar glands.



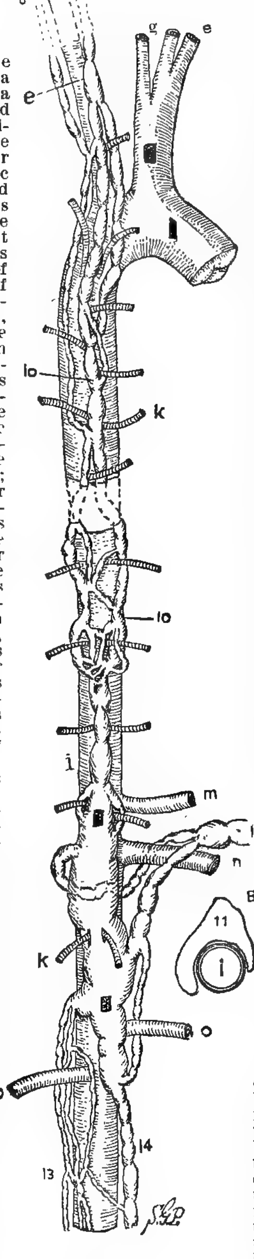
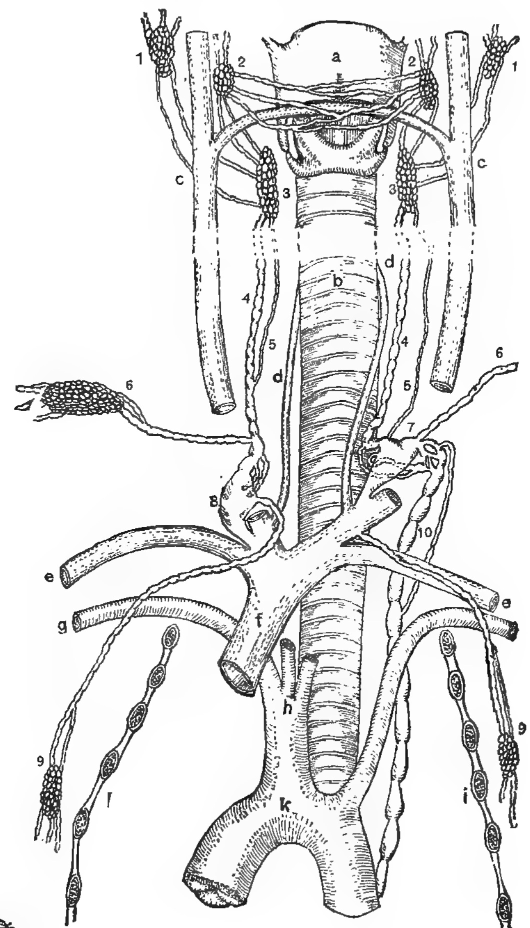


Fig. 3283.

Fig. 3283.—Dorsal View of the Chylocyst and the Great Lymphatic Trunks in their Relation to the Blood-vessels of the Cat (*Felis Domestica*). Slightly more than natural size. The blanks and dotted lines indicate the omission of a part of the length. (Drawn by Mrs. Gage.) *a*, *a*, External jugular veins; *b*, *b*, internal jugular veins; *c*, *c*, subclavian veins; *d*, precava; *e*, the right and left subclavian arteries; *f*, left thyroid axis; *g*, between the two carotid arteries; *h*, brachiocephalic artery; *i*, *i*, *i*, aorta; *k*, *k*, upper one an intercostal, lower a lumbar artery; *m*, cœliac axis; *n*, superior mesenteric artery; *o*, *o*, renal arteries. 1, Left jugular lymphatic trunk, bifurcating and joining the thoracic duct; 2, right jugular trunk, bifurcating and one branch joining the right common lymphatic trunk, the other terminating independently in the mesal aspect of the external jugular; 3, 3, trunks from the right and left prescapular glands; 4, 4, the two openings of the thoracic duct, the lateral one being at the junction of the subclavian and external jugular, the mesal one into the external jugular about opposite; 5, 5, the two openings of the right lymphatic trunks—they are similar in position to the openings of the thoracic duct; 6, 6, pectoral lymphatics; 7, 7, thoracic lymphatics (cf. 11 and 12 of Fig. 3282); 8, branch of the thoracic duct on the ventral side of the great subclavian vessels, sometimes the entire duct is on the ventral side; 9, branch of the thoracic duct on the dorsal side of the subclavian blood-vessels–this is the position of the entire duct in about three-fourths of the numerous specimens examined; 10, 10, greatly divided thoracic duct. The thoracic duct is never simple in the cat throughout its whole course, but this one is more than commonly divided; 11, 11, 11, chylocyst. On the right is drawn a section at this point to show that the chylocyst nearly embraces the aorta; 12, intestinal lymphatic trunk sending a large branch on both sides of the aorta to enter the chylocyst; 13, left lumbar trunk greatly divided; 14, right lumbar lymphatic trunk anastomosing with the left and with a branch from the intestinal trunk.

lymphatica dextra).—The right common lymphatic trunk is only about 14 mm. long, but is nearly as great in diameter as the thoracic duct. It is formed by the confluence of the lymphatics from the right side of the head (*truncus lymphaticus jugularis dexter*), those from the right arm, shoulder, and breast (*truncus lymphaticus subclavius*), the efferent trunks from the right half of the sternal, and ventral mediastinal and bronchial plexuses (*truncus bronchomediastinalis dexter*). As stated above, a part of the lymphatics of the right costal region open into the left thoracic duct (Fig. 3280). As on the left side there is a tendency for the trunk to terminate by a multiple instead of a single opening. Not infrequently, there is no true common trunk formed, but the great trunks from the different regions open separately.

The great lymphatic trunks in the higher mammals conform quite closely to those of man, but the termination varies somewhat. When the internal jugular is small it is generally near the junction of the subclavian and external jugular (Figs. 3282, 3285, and 3287), in the horse



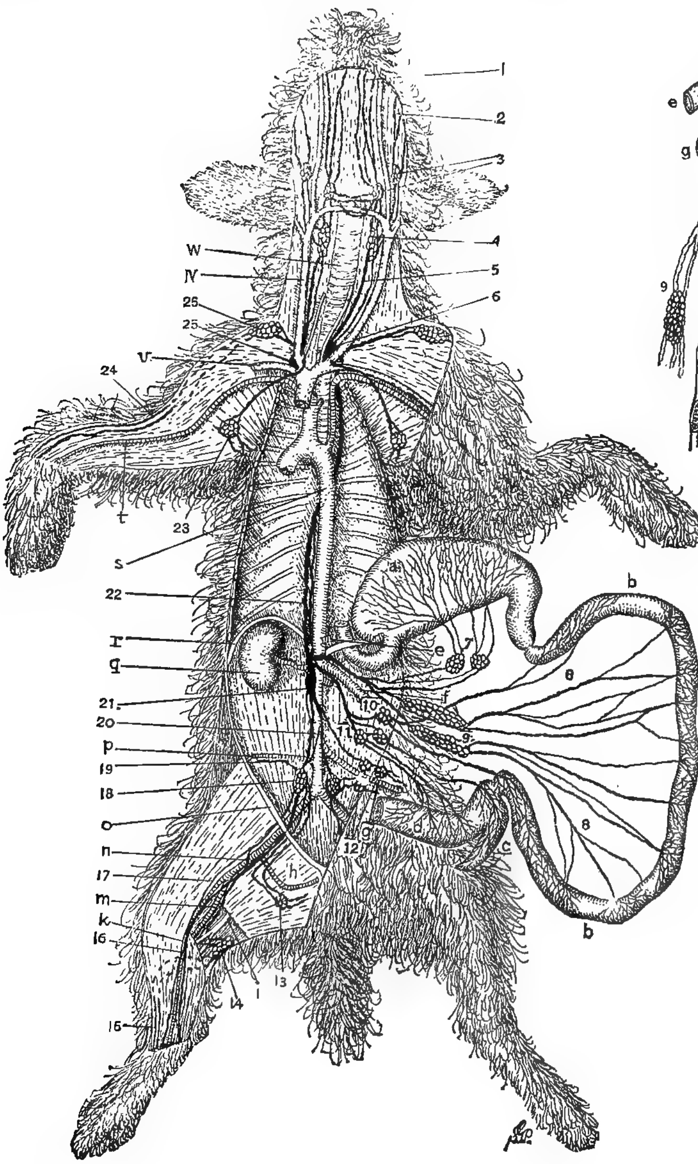


FIG. 3284.

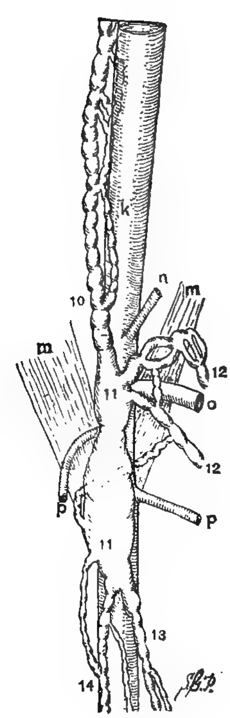


FIG. 3285.

Lymphatic System.

FIG. 3284.—General View of the Lymphatic System of the Dog (Scotch Terrier). (Drawn by Mrs. Gage.) *a*, Stomach; *b*, *b*, small intestine; *c*, cæcum; *d*, large intestine; *e*, cœliac axis; *f*, superior mesenteric artery; *g*, inferior mesenteric artery; *h*, epigastric artery displaced from the abdominal wall to the muscles of the thigh; *i*, sciatic nerve and other popliteal structures brought into view by removing a segment of the thigh muscles; *k*, saphenous or internal cutaneous artery; *m*, *n*, the femoral artery; *o*, cut edge of the abdominal wall; *p*, ilio-lumbar artery; *q*, right kidney; *r*, cut edge of the diaphragm; *s*, aorta; *t*, brachial artery and its continuation as the radial artery in the anti-brachium; *u*, subclavian vein; *v*, external jugular vein; *w*, trachea. 1, Lymphatic trunks from the ventral lip to the mesal of the two submaxillary lymphatic glands; 2, lymphatic trunks from the face and nose, and dorsal lip, injected from the snout; 3, the two submaxillary lymphatic glands with the facial vein between them—the mesal glands of the two sides are connected by several transverse vessels; 4, ental cervical gland; 5, jugular lymphatic trunk finally joining the thoracic duct on the left, the right lymphatic trunk on the right; 6, termination of the thoracic duct at the junction of the subclavian and external jugular veins; 7, cœliac glands receiving the lymphatics of the stomach, and sending efferent trunks to the intestinal trunk; 8, lymphatic or lacteal trunks from the small intestine; 9, two large mesenteric glands (so-called glands of Asellius or pancreas Asellii; from these originates the intestinal lymphatic trunk, which is quite short in the dog and much more difficult to inject than in the cat; 10, gland receiving trunks from the duodenum, ileum, and large intestine near the cæcum; 11, glands receiving the lymphatics from the cæcum, and part of the large intestine; 12, glands in the mesocolon along the inferior mesenteric artery; they receive vessels from the large intestine, and the efferent vessels go to the chylocyst and to the lumbar glands; 13, gland on the abdomen beside the external epigastric artery; 14, popliteal gland; 15, lymphatics from the foot, following the external or short saphenous vein around the calf of the leg into the popliteal gland; the parts of the vessels that would be hidden in this view are indicated by broken lines; 16, lymphatic trunk following the saphenous artery. The saphenous trunk freely anastomoses with the trunk following the femoral artery, and with it passes to the lumbar glands; 18, lumbar lymphatic glands; 19, lymphatic trunk, accompanying the ilio-lumbar artery, and terminating in the lumbar glands; 20, lumbar lymphatic trunks; 21, chylocyst; 22, thoracic duct, double for a considerable distance; 23, pectoral lymphatic gland and vessels; 24, lymphatic trunks following the cephalic vein, and terminating in the prescapular gland. The course along the brachium is indicated by broken lines, as the vessels would not appear in this view; 25, termination of the right lymphatic trunk; 26, prescapular lymphatic gland of the right side.

FIG. 3285.—Ventral View of the Chylocyst and the Great Lymphatic Trunks in their Relation to the Principal Blood-vessels of the Dog (Scotch Terrier). The blanks with dotted lines in the cervical region, and the blank in the thorax, indicate that part of the length has been omitted. About natural size. (Drawn by Mrs. Gage.) *a*, Larynx; *b*, trachea; *c*, *c*, the right and left external jugular veins, with segments removed; *d*, *d*, the two internal jugular veins; *e*, *e*, subclavian veins; *f*, precava; *g*, *g*, right and left subclavian arteries; *h*, brachio-cephalic artery, near its division into the subclavian and the two carotids; *k*, *k*, aorta; *m*, *m*, pillars of the diaphragm; *n*, *n*, cœliac axis; *o*, superior mesenteric artery; *p*, *p*, renal arteries. 1, 1, Right and left lateral submaxillary lymphatic glands, receiving trunks from the face, nose, and dorsal lip; 2, 2, mesal submaxillary lymphatic glands, receiving trunks from the ventral lip; these two glands are connected by numerous anastomosing and crossing trunks; 3, 3, ental cervical glands, receiving the efferents from 1 and 2; 4, 5, 4, 5, jugular trunks from the ental cervical glands to the thoracic duct and right common lymphatic trunk; 6, 6, trunks from the prescapular glands, only the right gland being shown; 7, termination of the thoracic duct on the mesal surface of the external jugular, near its junction with the internal jugular vein. The arch in the duct is on the dorsal side of the great subclavian vessels, and it arches toward the meson instead of laterad as with the cat, and before terminating enlarges considerably. Into the enlargement terminate the jugular trunks and the one from the prescapular gland; the enlargement narrows markedly before entering the vein; 8, enlargement and termination of the right lymphatic trunk; 9, 9, pectoral glands and trunks; the one on the left terminates independently in the lateral aspect of the external jugular, near its junction with the subclavian; 10, 10, thoracic duct; it is considerably divided just within the thorax, and then again just before enlarging near its termination; 11, 11, chylocyst on the ventral and right side of the aorta, and extending for a short distance into the thorax; 12, 12, intestinal lymphatic trunks; one branch winds round the left side of the aorta, and terminates finally on the right side of the chylocyst; 13, left lumbar lymphatic trunk; 14, right lumbar lymphatic trunk.

FIG. 3286.—General View of the Lymphatic System of a White Rabbit. (Drawn by Mrs. Gage.) *a*, Stomach; *b*, *b*, small intestine; *c*, *c*, cæcum; *d*, the so-called vermiform appendix; *e*, large intestine; *f*, cœliac axis; *g*, superior mesenteric, and *h*, inferior mesenteric artery; *i*, external epigastric artery displaced from the abdominal wall to the muscles of the thigh; *k*, sciatic nerve and other popliteal structures exposed by removal of a segment of the thigh muscles; *m*, saphenous or internal cutaneous artery; *n*, *o*, femoral artery; *p*, cut edge of the abdominal wall; *q*, ilio-lumbar artery; *r*, right kidney; the left has been omitted, although the beginning of the renal artery is shown; *s*, cut edge of the diaphragm; *t*, aorta; *u*, brachial and ulnar artery; *v*, subclavian vein; *w*, external jugular vein; *x*, trachea. 1, Trunks from the ventral lip and sides of the mouth; 2, trunks from the snout; 3, the two submaxillary lymphatic glands on either side of the facial vessels; 4, lymphatic glands near the base of the ear; 5, ental cervical lymphatic gland; 6, left jugular lymphatic trunk on its way to join the thoracic duct; 7, thoracic duct near its termination in the vein; 8, cœliac glands, receiving the lymphatics of the stomach; 9, 9, lacteals from the small intestine to 10, the great mesenteric gland (gland or pancreas of Asellius); it gives rise to two intestinal trunks, which are short, small, and difficult to inject with a coarse mass; 11, large mesenteric gland receiving the vessels from the mass of lymphoid follicles at the termination of the ileum; 12, lymphoid tissue, *sacculus rotundus*, at the termination of the ileum; 13, gland receiving the lymphatic trunks from the vermiform appendix; 14, glands in the mesocolon along the inferior mesenteric vessels; the efferent vessels pass to the lumbar trunks; 15, hypogastric or sacral lymphatic gland; 16, gland on the abdomen by the external epigastric vessels—it has been displaced with the artery to the thigh muscles; 17, popliteal glands receiving vessels from both sides of the crus, sending efferent branches between the peroneal and tibial nerves to follow the femoral artery, and another to accompany the ischiadic artery; 18, lymphatic trunks from the dorsum of the foot, winding round the tibial or outer side of the calf to join the popliteal gland; 19, lymphatic following the saphenous artery; it usually divides near the knee, sending one branch to the popliteal gland; 20, lymphatic trunk extending along with the femoral artery; it is formed by the intimate anastomosis of those accompanying the saphenous and deep femoral arteries; 21, lumbar lymphatic glands; 22, subcutaneous lymphatic gland near the ilio-lumbar blood-vessels, just at the lateral margin of the sartorius muscle; the efferent lymphatics follow the ilio-lumbar vessels and enter the lumbar glands; 23, lumbar lymphatic trunks; the right one is much more divided than the left; 24, chylocyst; 25, thoracic duct; this is almost invariably more or less divided and sends out a considerable branch to the right lymphatic trunk; 26, pectoral lymphatic glands; 27, anasto-

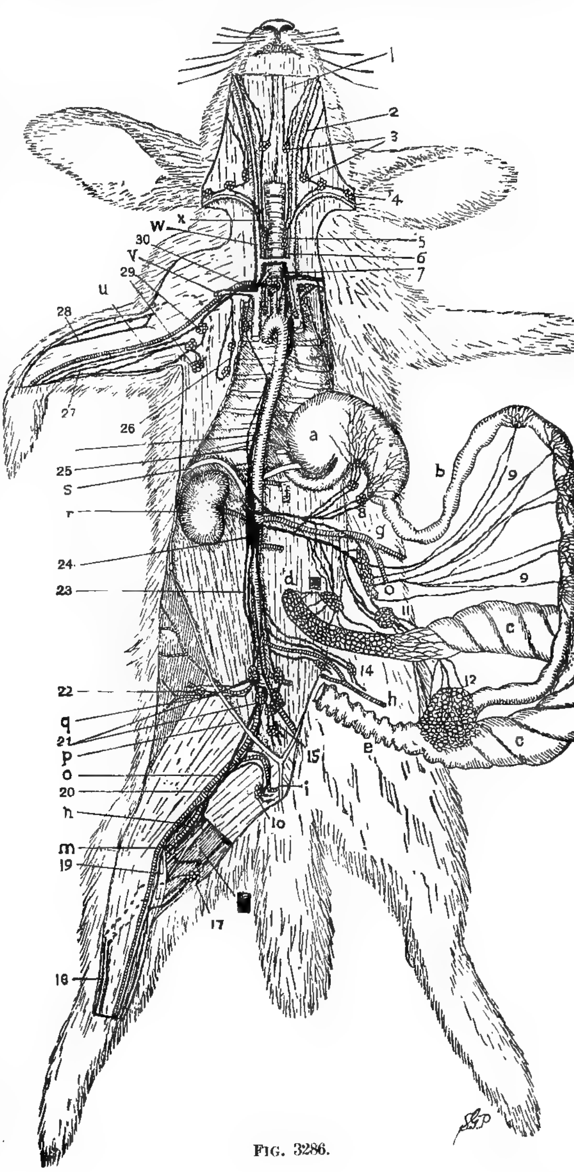


FIG. 3286.

mosing trunks following the radial and brachial artery to the axillary glands; 28, trunk following the radial nerve, winding round the brachium to terminate in the axillary glands also; the broken line indicates that the trunk would be out of sight in this view: 29, axillary lymphatic glands: these are not very closely connected with the axillary vessels; 30, termination of the right lymphatic trunk.

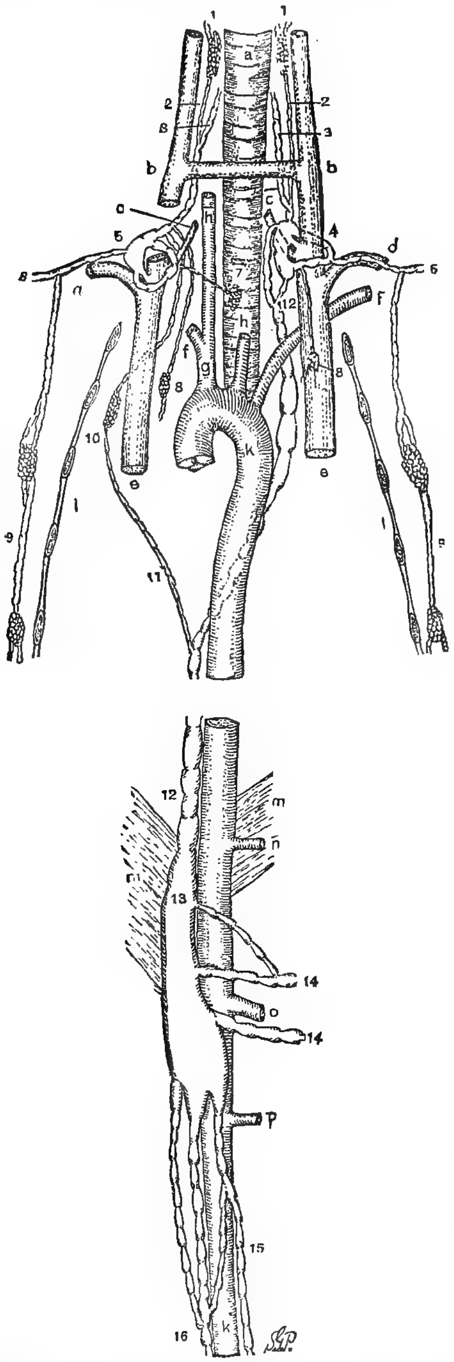


Fig. 3287.—Ventral View of the Chylocyst and the Principal Lymphatic Trunks in their Relation to the Great Blood-vessels in the White Rabbit. (Drawn by Mrs. Gage.) *a*, Trachea; *b*, *b*, external jugular veins connected by a transverse vessel; *c*, *c*, internal jugular veins; on the right a segment is removed from the jugular better to show the branches forming the right lymphatic trunk; *c*, *c*, the two internal jugular veins; *d*, *d*, the subclavian veins; *e*, *e*, the right and left precavæ; *f*, *f*, the two subclavian arteries; *g*, brachiocephalic artery dividing into the right subclavian and the right carotid; *h*, *h*, carotid arteries, the left arises from the arch of the aorta; *i*, *i*, cut thoracic wall and ends of five of the ribs; *k*, *k*, aorta; *m*, *m*, pillars of the diaphragm; *n*, cœliac axis; *o*, superior mesenteric artery; *p*, left renal artery, the right not being shown. 1, 1, Two ental cervical glands; 2, 2, efferent trunks of the ental cervical glands; 3, 3, ectal lymphatic trunks from the glands near the ear; they follow the external jugular vein for a considerable distance, then penetrate the tissues to join the jugular trunk; 4, the termination of the thoracic duct; this is very complex, forming a ring around the jugular, and becoming ampulliform, it terminates by a narrowed neck at the junction of the external and internal jugular veins; the numerous trunks opening into the expanded end of the thoracic duct, have their mouths guarded by a paired valve; 5, termination of the right lymphatic trunk; it is expanded like the thoracic duct and receives many trunks. The external jugular vein is encircled as on the left. A segment of the vein has been removed, better to show the parts. The right trunk opens into the vein at the junction of the right subclavian and external jugular, as is the usual method on both sides in the dog and cat; 6, 6, right and left trunks from the axillary glands; 7, tracheal gland with trunk going to the right; there is probably one going to the left also, as with the cat; 8, 8, glands in the thorax sending their efferent trunks to the corresponding common trunks; 9, 9, pectoral glands, and trunks on the two sides; their efferent trunks unite with those from the axillary glands to form the subclavian lymphatic trunk; 10, lymphatic gland on the right, near the second rib, through which passes the branch from the thoracic duct to the right lymphatic trunk; 11, branch of the thoracic duct going to the right side: this right branch is a very frequent, if not a constant, feature in the rabbit; 12, 12, thoracic duct; it is frequently much more divided than is shown in this figure. The blank space near the middle indicates that a part of the length was omitted; 13, chylocyst; this is as in the dog and cat, inclined to the right side of the aorta, but it does not extend so far into the thorax; 14, intestinal lymphatic trunk; this is small, usually multiple, short, and difficult to inject with a coarse mass; 15, 16, the right and left lumbar trunks; they form a long-meshed network, and in this specimen terminate in the chylocyst by three trunks.

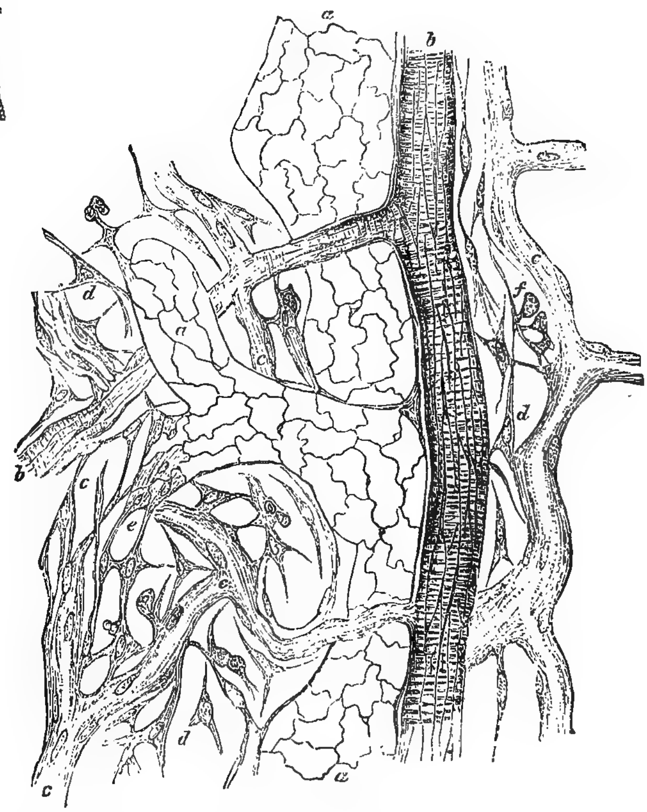


Fig. 3288.—A Pencilled and Silver-stained Preparation of the Normal Omentum of a Rabbit, to Show the Relation of the Blood- and Lymph-vessels to the Tissue Cells. (Klein.[7]) *a*, Lymphatic capillary with the outlines of its endothelial cells stained with silver; *b*, small artery showing spindle-shaped endothelial lining, and two small branches to the left; *c*, capillary blood-vessels; *d*, branched cells in the surrounding tissue; *e*, direct continuation f the endothelium of a lymph capillary with branched cells of the surrounding tissue; these cells are also attached directly to the blood capillary; *f*, wandering cells.

Lymphatic System.

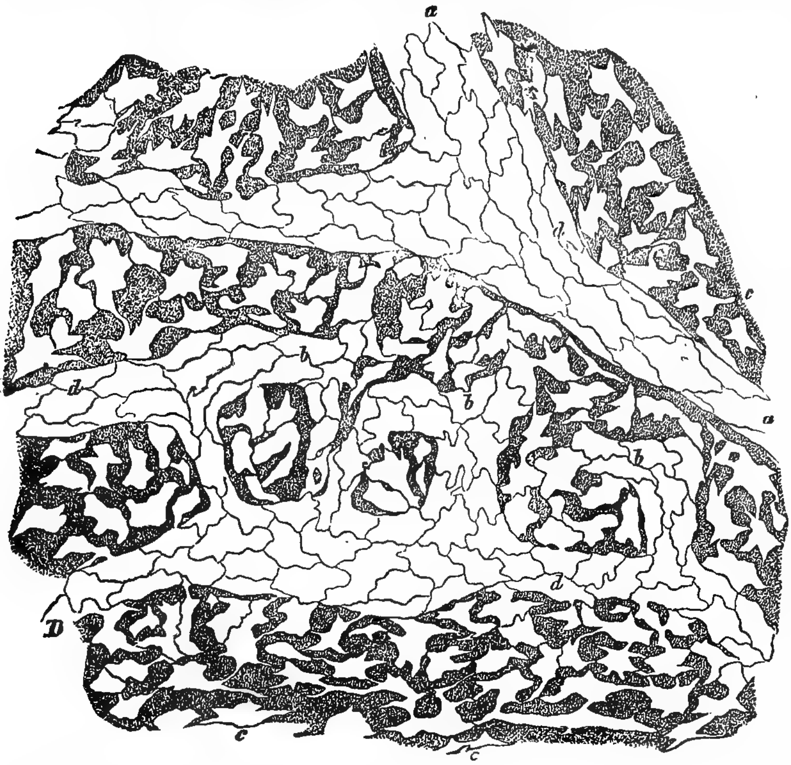


FIG. 3289.—Pencilled and Silver-stained Preparation of the Pleural Aspect of the Central Tendon of a Rabbit's Diaphragm, to show Lymphatic Capillaries and their Relation with the Cell Spaces. (Recklinghausen.[8]) Magnified 300 diameters. b, Beginning of the lymph capillaries by a continuity with the cell spaces; c, c, c, cell spaces surrounded by the dark ground substance. These spaces contain cells, lymph-canalicular cells, and the cell processes partly fill the white lines connecting the cell spaces (cf. Fig. 3288). d, d, d, d, Lymphatic capillaries with the serrated endothelial cells.

mals both trunks tend to open by two or more mouths (Fig. 3283), and in all the thoracic duct shows a strong tendency to conform to the lymphatics in general and break up into a kind of network instead of remaining of considerable size. Sometimes this network encloses the aorta, but more frequently it assumes the condition shown in Fig. 3283. In the rabbit almost constantly, and very frequently in the cat, there is a branch of the thoracic duct extending to the right (Figs. 3282 and 3287).

The chylocyst is large in the dog, cat, and rabbit, and in many other animals, and there is a strong tendency for its component trunks (intestinal and lumbar) to divide before entering it, so that it is formed by the union of a coarse network rather than by a few simple vessels (Figs. 3282, 3283, 3285, and 3287).

In the non-mammalia, birds, reptiles, amphibia, and fishes, the great trunks are symmetrical, that is, nearly equal on the two sides. They open into the great veins near the heart. There is also a pair of vessels opening into the ischiadic or other pelvic veins, and in the frog and toad there is a lymph heart on each great trunk, near the opening. In the non-amphibian forms, where lymph hearts are present, they are confined to the pelvic region. (See under Development, below.)

this duct terminates in the precava, and in the ox usually at the junction of the left jugular and the precava. In the ox also it usually traverses a special opening in the diaphragm. In the horse the duct is dilated at its termination, as it is also in the dog and rabbit (Figs. 3285 and 3287); in all the ani-

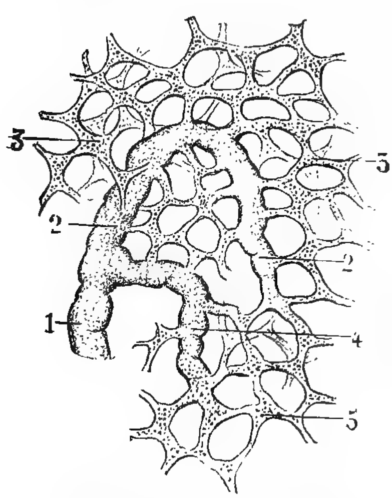


FIG. 3290.—Formation of a Lymphatic Capillary in the Skin of the External Ear. (Sappey, Atlas.) 1, Lymphatic capillary; 2 and 4, two minute branches uniting to form the larger capillary; 3, 3, 3, lacunes or dilatations formed by the union of the minutest lymphatic vessels, the capillicules. The union of a multitude of these lacunes forms a lymphatic capillary. This is shown best at the lower part of the figure.

ORIGIN AND STRUCTURE OF THE LYMPHATIC VESSELS.—There are three distinct views as to the ultimate origin of the lymphatic vessels: 1. That they are in direct communication with the blood-vessels at the periphery by means of connecting radicles so small that in normal conditions only the blood plasma can traverse them, and that under pathological conditions these connecting radicles may increase sufficiently in size to admit the passage of blood-corpuscles. This was one of the earliest views, and it is supported by the fact of the ready appearance of water or even colored gelatin in the lymphatics soon after the blood-vessels were injected. This was, and

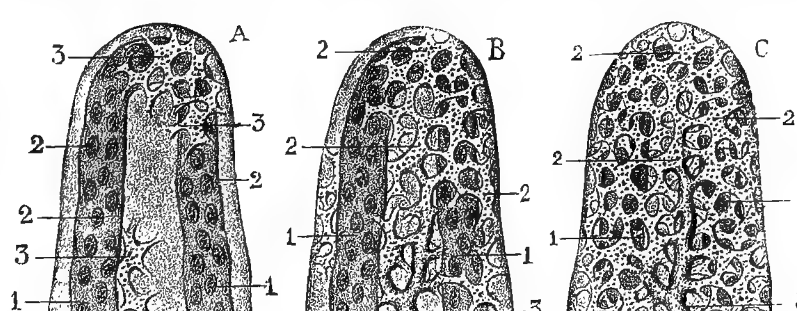


FIG. 3291.—A Simple Papilla from the Corium of the Hairy Skin of the Head, showing the Blood-vessels and Three Stages of Lymphatic Injection. (Sappey, Atlas.) A, A papilla, the simple blood-capillary loop (1 and 2) with very few lymphatic lacunes (3) and no sign of a lymphatic capillary. B, The lymphatic capillary (3) has appeared, and the lymphatic lacunes and capillicules (2) are very prominent, but the blood-capillary loop (1) is still evident. C, The blood-capillary loop (1) is almost invisible from the dense network of lymphatic lacunes and capillicules (2); the lymphatic capillary (3) is prominent. This series is an excellent illustration of the structures that remain invisible in ordinary preparations. Probably in very few histological preparations are more than half or one-third of the structures seen.

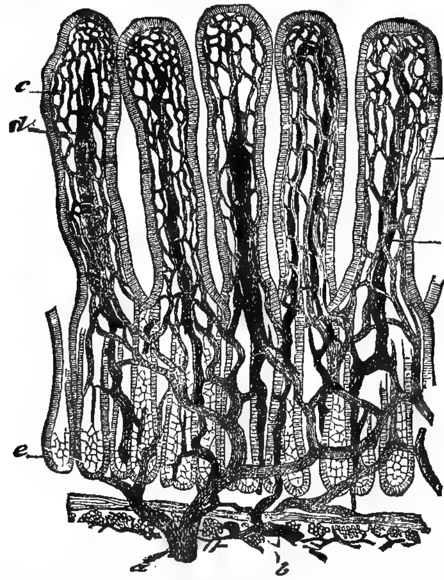


FIG. 3292.—Lacteals of the Intestinal Villi of the Dog. (Cadiat.) *a*, Artery extending into the villi to form a capillary network (light shading); *b*, lacteal extending from the villi into the submucosa (dark shading); *c*, *c*, blood capillaries in the villi; *d*, *d*, central lacteal of the villi. In one it forms a loop, in the others it ends blindly; *e*, crypts of Lieberkühn.

still is, a favorite method of demonstrating the lymphatics of an organ. In objection to the doctrine of the direct connection of the two systems of vessels, it was

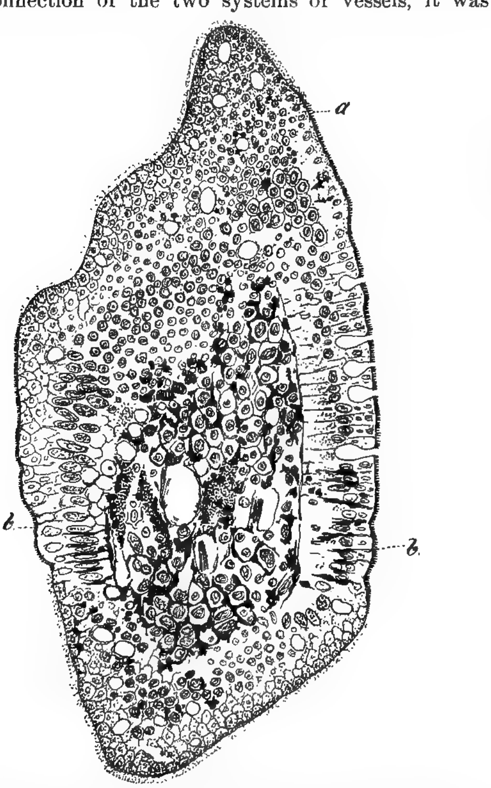


FIG. 3293.—Transection of a Villus (Mall [14]) in which the Lymphatics have been Injected with Berlin blue. The blue is represented by black in the figure. From the centre fine streams of the injecting mass have penetrated to the epithelium and even between the epithelial cells. *a*, sectional view of the epithelial cells with the lymph channels in section; *b*, *b*, longisections of the epithelial cells showing the lymph channels between them.

pointed out by Hunter that, when the coarser matters injected into the blood-vessels appeared in the lymphatics, it was due to a breakage somewhere in the wall of the blood-vessel; and further, that the filling of the lymphatics by injecting water or gelatin into the blood-vessels was but natural, as it is one of the properties of the blood-vessels to allow the contents to diffuse through their walls, and the lymphatics, from their office as a drainage system, take up the exuded liquid. This does not, however, show how the exuded liquid gets into the lymphatics. The pressure which forces the plasma through the walls of the blood-vessels would seem rather to collapse the lymphatics, as the pressure is on the outside. In a word, there has been no conclusive proof

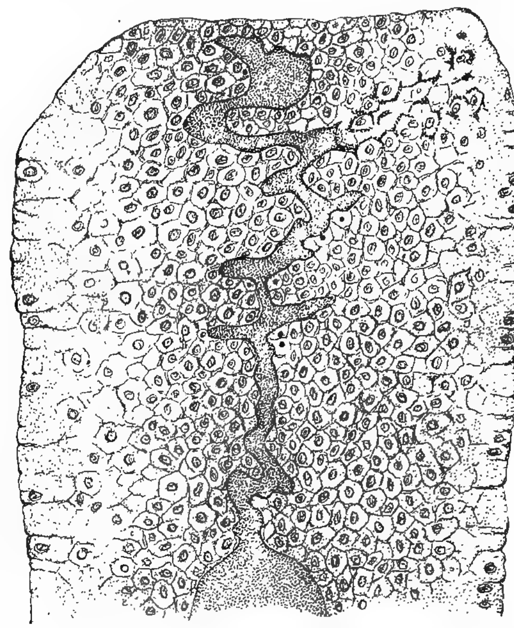


FIG. 3294.—Longisection of the Terminal Part of a Villus (Mall [14]) to show the narrow, spiral extension of the central lacteal, with fine branches reaching out from it toward the surface. The epithelium has been removed and the lymphatics have been injected with Berlin blue (cf. Plate XLIV. and Fig. 3293).

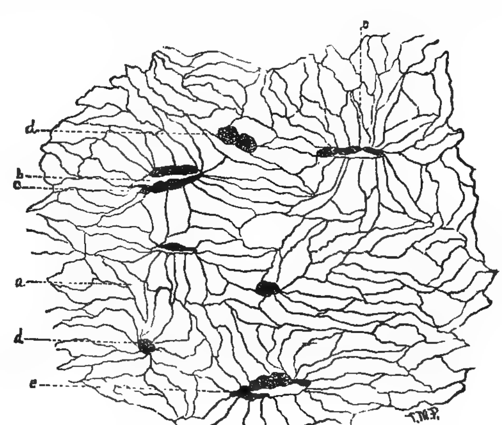


FIG. 3295.—Portion of the Cisterna Lymphatica Magna of the Frog, to show Endothelium and Stomata. (Prudden.) *a*, Ordinary endothelial cells, the nuclei not being shown; *b*, *b*, stomata leading from the peritoneal cavity into the dorsal lymph sac; *c*, *c*, germinating endothelium surrounding the stomata; *d*, germinating endothelia among the ordinary cells; these are frequently called pseudostomata.

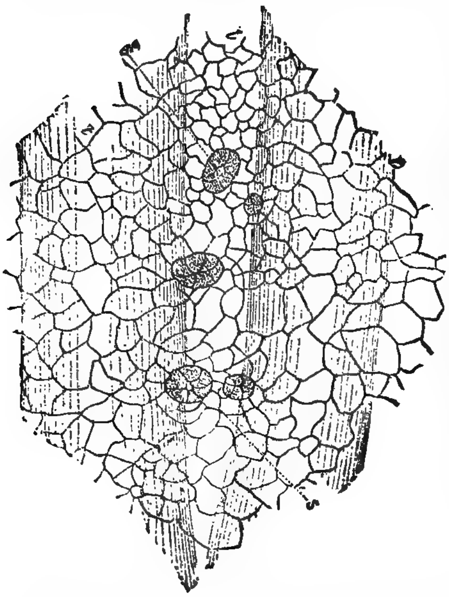


FIG. 3296.—Silver-stained Peritoneal Aspect of the Central Tendon of a Rabbit's Diaphragm, to show Stomata. (Klein.[7]) *l*, Lymph channel between the tendon bundles; *s*, *s*, five stomata, surrounded by germinating endothelium and leading into the lymph channel between the two tendinous bundles. Part of the stomata are open and part closed; *t*, *t*, two bundles of the central tendon, between which is the lymph channel into which the stomata open. Over the tendinous bundles the endothelial covering is composed of markedly larger cells than over the lymph channel.

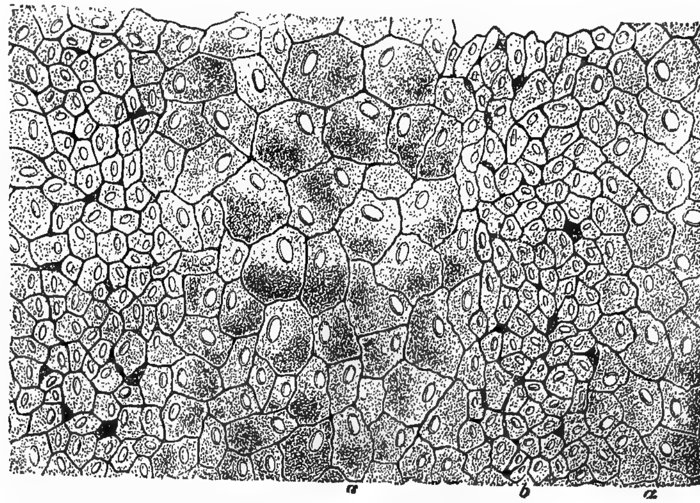


FIG. 3297.—Peritoneal Endothelium from the Central Tendon of the Rabbit's Diaphragm, to show the Difference in the Size of the Cells, and the Pseudostomata between them. (Klein.) *a*, *a*, Irregular rows of large nucleated endothelial cells, corresponding to underlying tendinous bundles; *b*, rows of smaller endothelial cells with numerous pseudostomata between them (the dark spots). The rows of small cells correspond to the lymph channels between the bundles (cf. Fig. 3296).

given that there is or is not a direct connection between blood-vessels and lymphatics.

2. That there is a network of minute spaces in the tissues between and around the individual structural elements, through which the diffused plasma slowly moves, bathing all the cells and fibres, giving to them oxygen and the other nutritive elements, and taking in return carbon dioxide and the other products of waste. Part of this waste, especially the carbon dioxide, diffuses back into the blood capillaries. This system has been called *juice spaces and canals* by Recklinghausen [8] and the *lymph-canalicular system* by Klein.[7] These minute channels and spaces are all interconnected and continuous with the

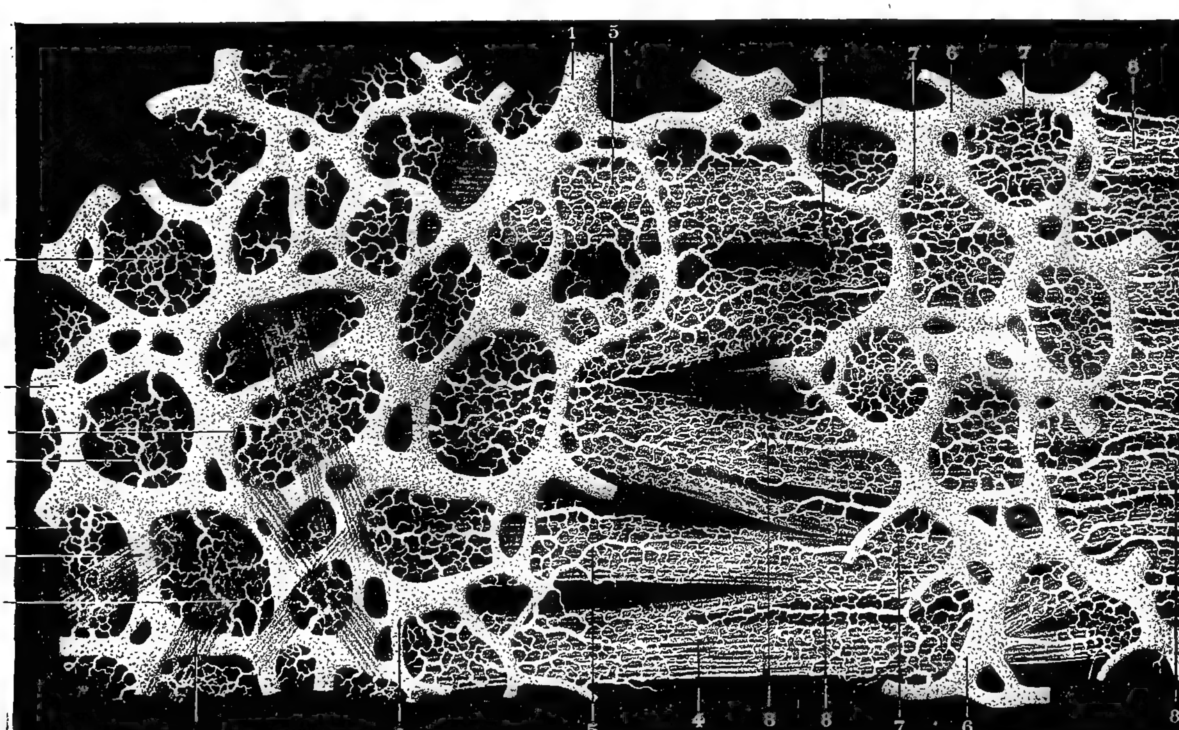


FIG. 3298.—Finer and Coarser Lymphatic Network of the Muscularis of the Small Intestine of a Child at Birth. (Sappey, Atlas.) Magnified 200 diameters and reduced about one-third. 1, 2, and 6, Coarse network of lymphatics resting upon the longitudinal muscles; 3, 4, 5, 7, and 8, finest lymphatic network around the muscular fibres, and uniting to form the larger network.

blood-vascular system through the intercellular cement and spaces, and with the lymphatic vessels in the same way, and further, these spaces frequently, if not constantly, contain branched cells, the cell body filling the

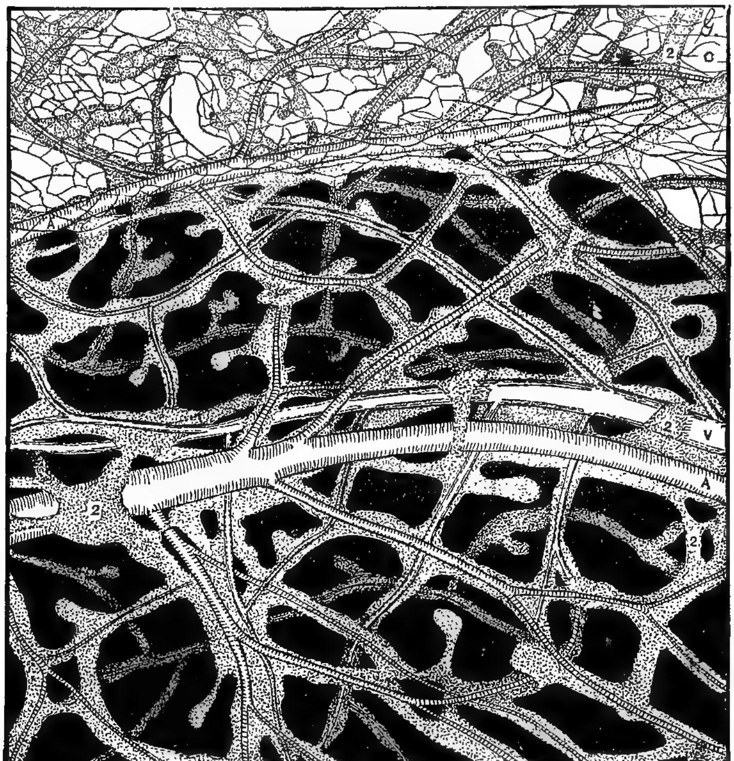


FIG. 3299. Surface View of the Lymphatic Network in the Submucosa of the Rabbit's Cæcum, showing the Form of the Network and the Relation of the Lymphatics and Blood-vessels. Magnified 55 diameters. (Drawn by Mrs. Gage.) *A*, *A*, Small arteries; *V*, small vein; *C*, the blood capillaries in the upper part of the figure; 2, 2, 2, 2, lymphatic vessels. (cf. Fig. 3300.) Throughout the entire figure is shown the tendency of the lymphatics to follow the blood-vessels and partly to surround them. The preparation was made by injecting Hoyer's chrome yellow mass into the appendix vermiformis, when it extended into the submucosa of the adjoining part of the cæcum (see Fig. 3286). The blood-vessels were then injected with fine red gelatin mass from the superior mesenteric artery. After the gelatin had cooled the cæcum was distended with alcohol, and the preparation finally mounted in Canada balsam.

larger spaces and the processes the connecting channels. These cell processes are often projected between the endothelial lining of the capillaries, thus forming the so-called pseudostomata, and therefore bring the lymphatics and blood-vessels really into continuity by the intervening cells and the spaces surrounding them. This is well shown at *e*, in Fig. 3288.

3. The third view is that of Sappey, who has represented with marvellous clearness the entire lymphatic system from origin to termination. He believes, and thinks he has proved by new and special means of research, that the lymphatic system at its origin is invariably composed of minute vessels (capillicules) from 1 μ to 4 μ in diameter, with structureless walls, which extend around and between all the structural elements. These capillicules are closed at the free end, but join, in nearly the same way as do the canaliculi of bone, to form somewhat larger spaces, the lacunes, which vary from 2 μ to 8 μ in diameter, and like the capillicules have structureless walls. By the union of many lacunes the true lymphatic capillaries are formed, and in them first appears the endothelial lining. Further, although the capillicules around and between the structural elements have blind terminations, those connected with the blood-vessels extend into the lumen between the endothelial cells, and have open mouths into which the plasma of the blood can freely enter, and in some pathological conditions they may become so large that the blood corpuscles may pass through the capillicules to the lymphatic vessels. This view is in part a return to the original doctrine, and it also differs from the doctrine of the lymph-canalicular origin in excluding the cells from the spaces or lacunes, and in giving distinct but structureless walls to the capillicules and lacunes.

The second view seems to the writer to be more in accordance with the teachings of modern biology and histology, by which the body is shown to be composed of a continuous network of interconnected structural elements independent only in the form of blood corpuscles, lymph, and wandering cells, but all the other elements being united either by cell cement or by delicate protoplasmic processes, and any spaces left between the structural elements being filled by the product of cell activity, which is known as ground or intercellular substance. This is very abundant in some tissues, as cartilage, very slight in amount in others, as epithelia. All of these structural elements are constantly bathed with lymph, and it is more in accord with what is at present known of absorption and excretion (see articles *Absorption*, *Digestion*, and *Metabolism*) to suppose that the lymph depends for its movement in certain definite directions upon the action of the living cells rather than on merely physical conditions. From the latest and most satisfactory work on the development of the lymphatics (see below) it would appear that the lymphatic system is a closed one, and all passage of lymph to it from the tissues or vice versa, must take place by diffusion as with the blood-vascular system.

The readily demonstrated or apparent origin of the

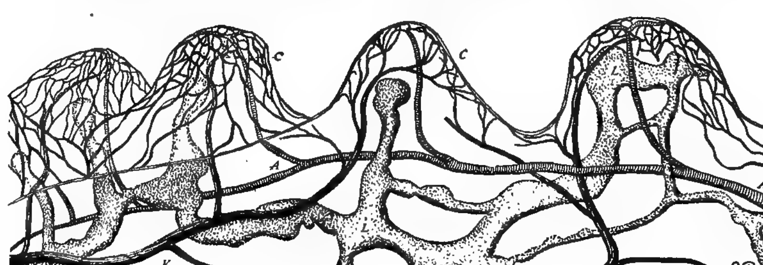


FIG. 3300.—Side View of the Lymphatics and Blood-vessels in the Cæcum of the Rabbit. (Drawn by Mrs. Gage.) *A*, *A*, artery; *V*, *V*, veins; *L*, *L*, lymphatics; *C*, villi. This figure shows the villus-like elevations persisting in the cæcum of the rabbit (Hilton [12]) with the vascular and lymph vessels. It will be noted that the artery for each villus extends to the summit and breaks up a network of capillaries which form a kind of mantle or tent. The lymphatics show the usual appearance, but with a kind of network in the villus at the right. On the left the whole villus is present at the top; on the right the part toward the observer has been removed from the two villi.

lymphatic vessels is in a plexiform network of valveless capillaries of varying sizes (Plates XLII., XLIII., and XLIV., and Figs. 3298 and 3299). From this capillary network extend collecting trunks with abundant valves (Fig. 3267). The serous cavities are likewise directly connected with the lymphatic vessels through the stomata or pseudostomata (Figs. 3295-3297). But the pleuro-peritoneal cavities are not primarily connected with the lymphatic system, but come to be so connected later.

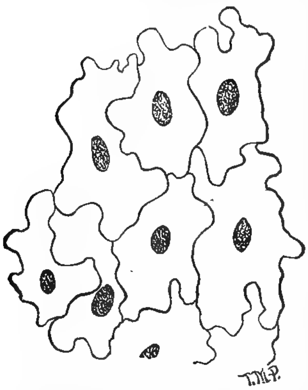


FIG. 3301.—Endothelial Cells from a Small Lymphatic Capillary of the Central Tendon of the Rabbit. This figure shows well the characteristic sinuous outlines and the nuclei of the endothelial cells. (Prudden.)

A distinct plexus of origin has been satisfactorily demonstrated in all the tissues and organs except the following, and in some of these, as the cornea, the lymph is known to circulate, although not in an independent network of vessels.

1. The central and peripheral nervous system and retina. The lymph in these situations is either in perivascular spaces or in perineural spaces. In the optic nerve, however, Key and Retzius figure a well-defined lymphatic network.

2. A lymphatic network has not been satisfactorily made out for bone or cartilage, and Sappey denies the presence of lymphatic vessels in these structures.

3. All forms of epithelia, including hair, nails, and teeth. But Klein figures and describes processes of branched cells projecting between epithelial cells and serving as lymph channels; but no distinct capillaries with endothelial walls are present. (See also Mall,[14] and Fig. 3293.)

4. Cornea and, according to Sappey, all forms of fibrous tissue, tendons, aponeurosis, fascia, and all serous membranes. Where a plexus of origin appears to be in these it belongs to the underlying tissue. According to many authors the connective tissue is a favorite place for the origin of the capillary lymphatic networks. There is no doubt of the presence of the network, the only question is whether it belongs to the connective tissue or to the surrounding tissues.

The ducts of some glands (as the pancreas) have never yet been shown to contain lymphatics, although in the ducts of other glands, as the liver, lymphatics have been shown in great numbers.

These networks or plexuses of origin show considerable variety in different parts of the body. As a rule, the lymph capillaries are considerably larger than the blood capillaries (Figs. 3299, 3300), and there is a great tendency to form blind, often ampulliform enlargements (Fig. 3300). In the villi of elongated narrow form, the origin by a blind central vessel is normal, or there may be a simple loop instead (Fig. 3294). In man, where the villi are mostly short and broad, there is a complicated network something like the blood capillaries, except that the lacteal capillaries are much larger. The simple blind end and loop are also seen in some of the more elongated villi. The presence of ampulliform enlargements, or even blind endings, in a vessel is not enough to determine whether it is a blood-vessel or a lymphatic, for some blood-vessels in muscle (Ranvier) and in the dura of the brain (Key and Retzius) have the form which is usually considered so characteristic of lymphatic vessels. The final test must be the connections of the vessel with a lymphatic gland or with an undoubted blood-vessel.

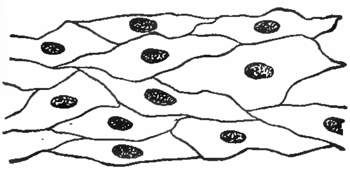


FIG. 3302.—Nucleated Endothelial Cells from One of the Larger Lymph Channels of the Central Tendon of the Rabbit's Diaphragm, to show the Elongated Form of the Cells in the Larger Vessels. Cf. Fig. 3301. (Prudden.)

Structure of Lymphatic Vessels.—Beginning with the lymph capillaries the wall is composed only of endothelial cells arranged mostly in the form of a tube. They may, however, be more like flattened clefts, the walls of which are in apposition except when containing lymph. The lining cells have sinuous edges (Fig. 3301). On the larger vessels the lining endothelium has more elongated cell outlines (Fig. 3302), and there progressively appear coats like those of the blood-vessels, except that they are thinner. The adventitia is easily separated from the vessel, is composed of a network of fine elastic fibres and a few longitudinally arranged muscular fibre cells. The middle coat has, besides the fine elastic tissue, many circularly arranged muscular fibre cells. This circular arrangement is not strictly adhered to, especially in the thoracic duct. Finally, the inner layer has its elastic fibres mostly in a longitudinal direction, and the endothelium covers the ental surface. In the thoracic duct there is usually a considerable addition of white fibrous tissue to the middle layer, and, as stated above, many of the muscular fibres of this layer may be oblique or even longitudinal. In general, then, the lymphatic vessels agree with the veins quite closely in structure. The amount and the fineness of the elastic tissue present is supposed to exert a marked influence in causing the speedy return of the vessel to its normal calibre after its distention by the lymph.

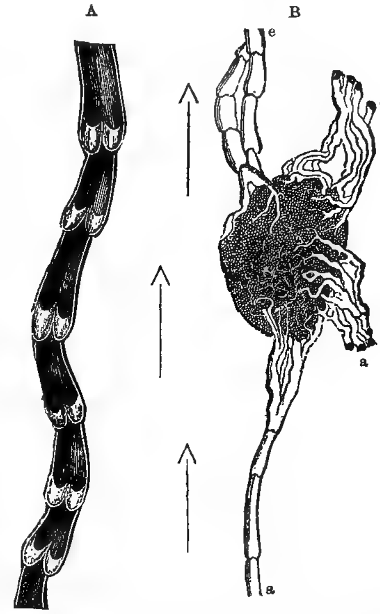


FIG. 3303.—Valves of a Lymphatic Trunk, and a Lymphatic Gland with its Afferent and Efferent Vessels. (Sappey.) *A*, Lymphatic trunk slit lengthwise and opened to show that the valves are in pairs—they are close together and they are at the level of the enlargements; further, that the intervalvular segments are in general of a conical shape, the apex of the cone pointing in the direction of the current, up in this figure. *B*, Lymphatic gland; *a*, *a*, *a*, the numerous afferent lymphatic vessels; *e*, the two voluminous efferent lymphatics.

Like the veins, the lymphatics are distinguished by the presence of valves; but they are much more abundant, there being, for example, sixty to eighty double valves from the hand to the axilla (Fig. 3303). In examining a well-injected preparation, it is very easy to determine the direction of the lymph stream as the segments of the vessel are approximately conical, the apex of the cone pointing in the direction of the stream (Fig. 3303). This is more marked in the smaller than in the larger vessels.

Valves are not found in the lymphatics of fishes, and are much less numerous in the other groups than in mammals.

Lymphatic Glands or Nodes and Lymphoid Tissue.—The lymphatic glands or ganglia or conglobate glands are rounded or flattened bodies placed in the course of the lymphatic vessels. These glands were known to Hippocrates, but were regarded by him as forming a part of the general glandular system. Naturally their true nature was discovered only after the discovery of the lymphatic vessels. In the higher mammals it is believed that no lymphatic vessel reaches one of the common terminal trunks without first traversing one or more of these glands. They first appear in the birds, or perhaps some of the highest reptiles, but lymphoid tissue is present in all the forms; and as the glands are practically concentrations of this lymphoid tissue their absence is not so important as might at first appear. The glands are sometimes solitary but usually are in groups or chains; they are mostly near blood-vessels, and so placed and loosely attached that they readily move aside to avoid pressure. In the limbs pressure is further avoided by position in the flexures of the joints. The glands vary greatly in number and size in the different mammals. In man they reach the highest number (five hundred to six hundred) and vary from a few millimetres to two or more centimetres in diameter.

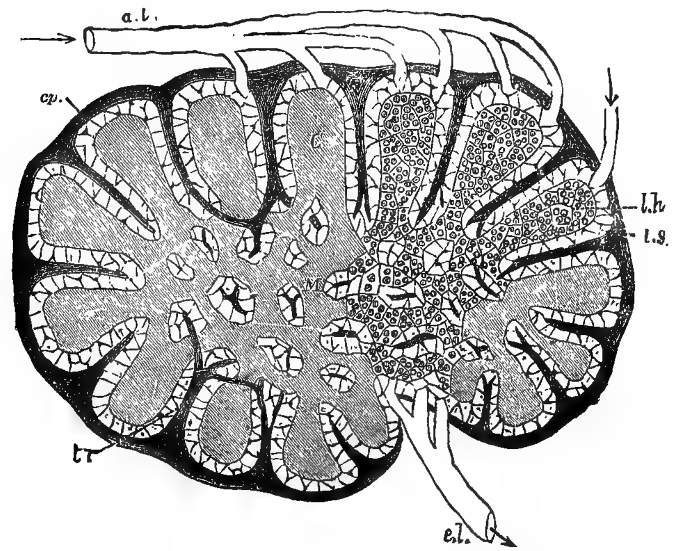


Fig. 3304.—Diagrammatic Section of a Lymphatic Gland. (Sharpey.) *a, l*, Afferent trunk breaking up into several smaller trunks before entering the gland; *e, l*, efferent lymphatic trunk formed by the union of several smaller trunks emerging from the gland (the arrows indicate the direction of the current); *C*, cortical glandular substance; *cp.*, capsule sending septa into the gland; *l.h.*, reticulated cords of medullary substance (it is shown in only a small part of the figure; the entire area shaded with lines possesses similar glandular substance); *l.s.*, lymph sinus or channel; *M*, central or medullary part of the gland (it is directly continuous with the cortical substance); *tr.*, trabeculæ or fibrous substance continuous with the capsule and forming a coarse meshwork in the gland (in this mesh is the proper gland substance).

Afferent and Efferent Vessels.—The vessel approaching a gland is said to be afferent or inferrent; the one leaving the gland is called efferent. On approaching a gland the afferent usually breaks up into several smaller vessels which enter the gland (Figs. 3303 and 3304). After traversing the gland the vessels leaving the surface unite usually in larger trunks than the afferent vessels, and continue to the next gland, where the process is repeated, or the vessel may terminate in one of the common trunks.

The structure of the lymphatic glands was long enigmatical. It was held by many, and is still so held, that the gland was really a kind of fine capillary network, like a renal glomerulus, or a rete mirabile, of blood-vessels; but it is now quite generally agreed that a lymphatic gland consists of the following parts: (1) A fibrous framework forming an enclosing capsule and sending into the interior a multitude of anastomosing trabeculæ. The capsule and larger trabeculæ may also contain muscular-fibre cells. (2) Embedded in the meshes of this fibrous network is the proper glandular substance, which consists of lymphoid tissue; that is, a fine network of branching and anastomosing cells and fibres containing in their meshes lymphoid corpuscles or young lymph cells. Near the surface of the gland the lymphoid tissue is arranged in quite regular masses (cortical lobes or aveoli) by the projecting trabeculæ (Fig. 3304). This is the so-called cortical portion, while in the central part (medullary portion) the lymphoid tissue is in more cylindrical masses (the medullary cylinders or lymphoid cords), but the tissue in the two parts is directly continuous. (3) The lymph sinus or channel. This is the path taken by the lymph in passing through the gland from the afferent to the efferent vessels. It is a narrow space filled with rather coarse retiform tissue, between the proper glandular substance and the fibrous framework (Fig. 3304, *l.s.*). The relations of this space may be clearly understood by comparing the fibrous framework to a mould and the proper glandular substance to the material poured into the mould and which, upon cooling, had shrunken evenly from the mould throughout the entire gland, thus leaving a narrow space which would represent the lymph channel. The afferent lymph vessel penetrates the sheath or capsule of the gland and pours its contents into the lymph sinus. The lymph then slowly

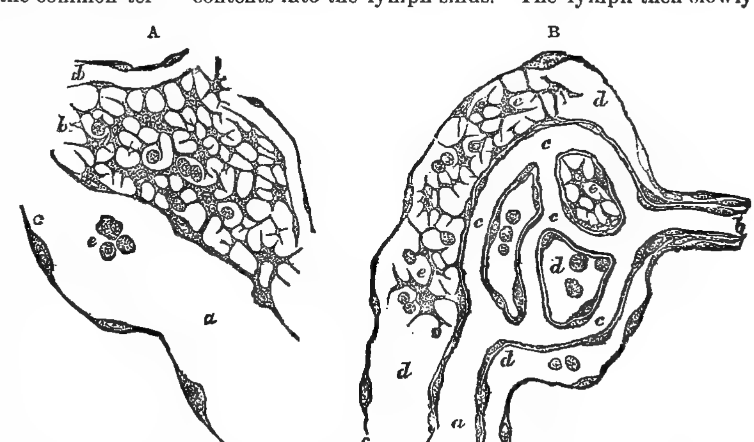


Fig. 3305.—Figures of Fresh Preparations of an Œdematous Omentum of a Guinea-pig suffering from Chronic Peritonitis, to Show Developing Lymphatic Nodules seen in Optical Section. (Klein.[7]) *A*, Perilymphatic or lymphangial nodule; *a*, lymphatic vessel; *b*, a portion of the lymphangeal nodule on the side of the vessel; *c*, endothelial wall of the lymphatic seen in profile; *d*, blood capillary of the nodule; *e*, lymph corpuscles in the lymphatic vessel (this nodule is like the reticular substance forming the proper glandular substance of the lymphatic glands, and as seen both in *A* and *B* the cells of the reticulum are in direct connection with the endothelium of the lymphatic vessel). *B*, An endolymphatic or lymphangial nodule in which the reticular tissue is within instead of being on the side of the vessel; *a*, vein; *b*, artery; *c*, blood capillaries; *d*, a lymphatic vessel enclosing the whole system of blood-vessels; *e*, reticulum of nucleated branched cells or lymphoid tissue connected with the wall of the lymphatic and filling the entire lumen.

Lymphatic System.

moves along the labyrinthine channels until it reaches the efferent vessels, when it enters them and continues toward the common lymph trunk. In passing through the sinus the lymph bathes the glandular substance and probably soaks into it. Along the edge of the channel the newly developed lymph cells enter the lymph stream and are carried along to the efferent vessel.

Blood-vessels are very abundant in the lymphatic glands and are found almost exclusively in the proper glandular substance. These blood-vessels are also accompanied by nerves. In some glands the efferent vessels and the blood-vessels are found mostly in a small depression which, in analogy with the kidney, has been called the hilus. This is not a marked feature and is absent in many cases.

In infancy and youth the glands near the surface are grayish in color while those in the interior of the body are pinkish. In adult and advanced life the glands are usually somewhat atrophied and darker in color, and those of the bronchial plexus are often dark brown or even black.

Lymphoid or adenoid tissue is like that described for the proper glandular substance of the lymphatic glands; that is, a fine network of branching and anastomosing cells or fibres with the meshes crowded with lymphoid cells. Sometimes this tissue is quite sharply defined, when it is called a follicle or simple lymphatic gland; in other situations it is diffuse. The tissue is abundantly supplied with blood-vessels, and the lymphatic vessels on its surface and emerging from the interior are in great abundance (Fig. 3306). The diffuse and follicular form of the tissue is found in great abundance in the alimentary canal of man and the lower animals. In the tonsils and the pharyngeal tonsil it is aggregated in considerable masses; so also in the Peyerian patches, which are simply an aggregation of lymph nodules, follicles, or solitary glands. The mucosa of the vermiform appendix of the rabbit (Fig. 3286) is almost entirely occupied by a great Peyer's patch; and the so-called solitary glands (Fig. 3306) are lymphoid nodules or follicles with a dense meshwork pervaded by blood capillaries and filled with lymph corpuscles. They are surrounded by a capillary network which helps to separate them somewhat from the surrounding less condensed lymphoid tissue (Fig. 3306).

Hæmolymph Glands.—Deep red or chocolate-colored bodies from 1 to 20 mm. in diameter with the general structure of lymph glands but with the sinuses filled with blood instead of lymph.

In structure the parenchyma of these glands resembles spleen or red marrow (splenolymph or marrow-lymph glands). The glands resembling spleen are most common. Intermediate or transition forms between hæmolymph glands and the ordinary lymph glands occur.

Hæmolymph glands have been reported in the following animals: Hen, turkey, rat, dog, sheep, goat, ox, pig, horse, and in man. They occur most frequently along the great blood-vessels, especially those of the abdomen. They are most easily found in the root of the mesentery,

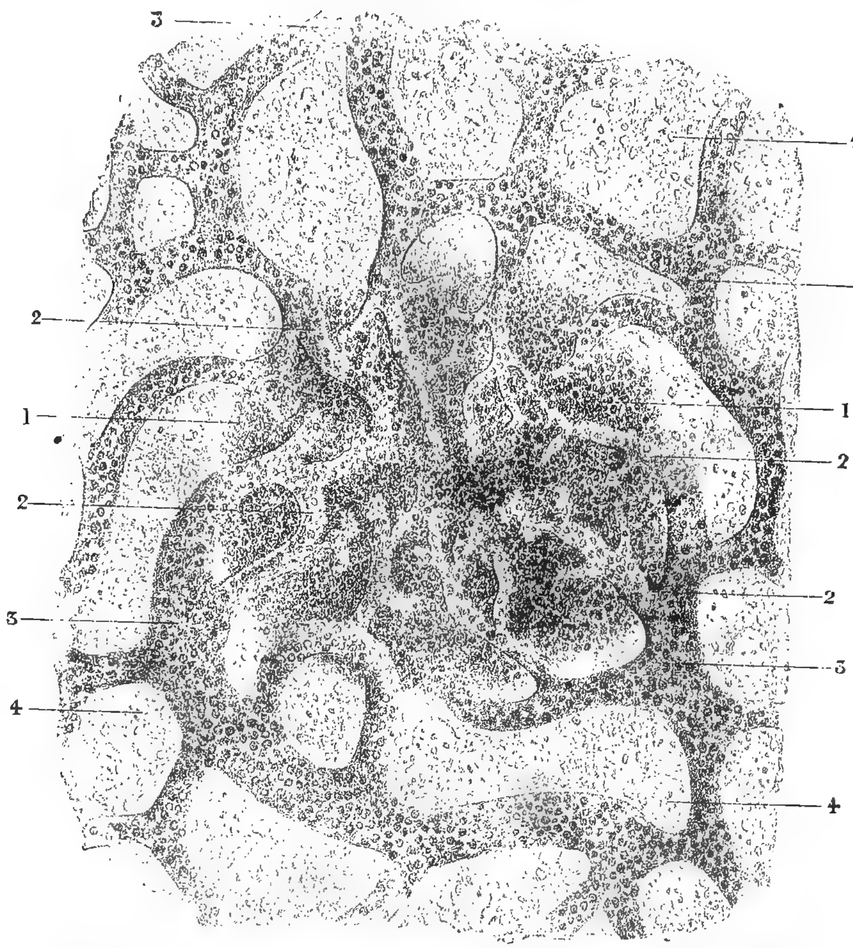


FIG. 3306.—Lymphatic Vessels arising from a Lymph Follicle or Solitary Gland of the Large Intestine of Man. (Sappey, Atlas.) Magnified 100 diameters and reduced about one-fourth. 1, Lymph follicle seen from the submucosa; 2, 2, 2, 2, lymphatic radicles arising in the depth of the follicle and appearing on the surface; 3, 3, 3, trunklets formed by the union of the smallest radicles; 4, 4, base of the crypts of Lieberkühn.

and in the neighborhood of the renal and adrenal vessels. In the cervical region they are commonly near the parathyroids (Warthin [9] and Vol. IV. of this Handbook).

Development of the Lymphatic System.—While in the past much serious study has been given to the development of the lymphatic system in the embryo, the matter has remained in a very unsatisfactory condition until recently. From the time when this system was discovered and worked out, in the adult it has been known that it is an appendage of the venous system. It has also been known for many years that the lymphatic system develops considerably later than the blood-vascular system. However, it is only within the present year (1902) that it has been shown conclusively that this system does not grow in from the exterior part of the body and finally form a union with the veins, *but on the other hand that it is a direct outgrowth of the venous system* (Sabin [10]).

As worked out for the pig it was found that the lymphatic system is at first symmetrical and grows out from the veins at four points, that is at the junction of the veins of the limbs with the cardinal veins, viz., at the junction of the subclavian and precardinal veins in the base of the neck, and in the lumbar region at the junction of the sciatic and femoral veins with the post-cardinals. Slightly beyond its origin from the vein each of the four original lymph trunks or ducts dilates to form a lymph sac or lymph heart. In lower forms, as the frog, lymph hearts contain striated muscle and are rhythmically contractile; it has not yet been shown, however, whether these sacs in the developing mammal are contractile or not.

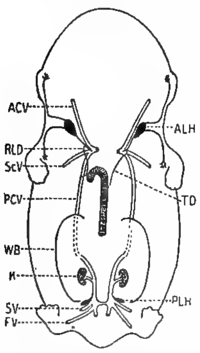


FIG. 3307.—Diagram of the Lymphatic System of an Embryo Pig 20 Mm. Long. × 2. (Sabin.) *ACV*, Precardinal vein; *RLD*, right lymphatic duct; *ScV*, subclavian vein; *PCV*, post-cardinal vein; *WB*, Wolffian body; *K*, kidney; *SV*, sciatic vein; *FV*, femoral vein; *ALH*, anterior lymph sac or lymph heart; *TD*, thoracic duct; *PLH*, posterior lymph sac or lymph heart. It is to be noted that the lymphatic system is symmetrical, but that in the cephalic part of the body it is considerably more advanced than in the caudal half.

As demonstrated in the following figures the lymphatics develop first in the cephalic half of the body; the system is symmetrical, but soon the left side preponderates; the connection of the lymphatics with the veins in the caudal half of the body is soon lost; there are very early two chylocysts, and two thoracic ducts, but as both thoracic ducts grow down to join the lumbar ducts from the left side, the asymmetry of the lymph trunks in the cephalic half of mammals is original and not secondary. It is also seen that the lymphatics as they grow out to the periphery are in a close-meshed network, the ends of the tubes forming the network ending blindly, and extending farther and farther over the body by a continual sprouting of the tubes.

The lymphatic glands are developed from a network of lymph vessels by an ingrowth of lymphoid tissue and by the formation of a connective-tissue capsule around the outside. Finally it should be stated that beginning with Kölliker in 1879 an increasing number of embryologists have come to believe that the real origin of the lymph corpuscles of the body is from the epithelial cells of the thymus (Beard [11]).

Methods. — The lymphatic vessels are so thin that unless they contain some liquid or solid they are not visible. One of the first ways of making the general lymphatics visible was to inject water or colored gelatin into the arteries of an organ. The mass exudes and fills the lymph vessels; this is especially successful if the vein is tied. The lacteals are made evident by feeding the animal some fatty food, like milk, an hour or two before death.

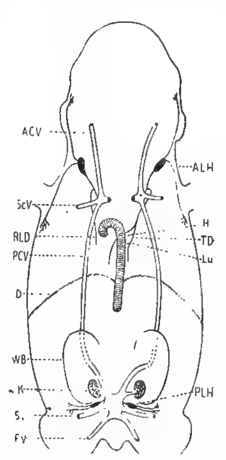


FIG. 3308.—Diagram of the Lymphatic System in an Embryo Pig 27 Mm. Long. × 2. (Sabin.) *D*, Diaphragm; *H*, duct to the heart; *Lu*, duct to the lungs. The other letters as in the previous figure. In this figure it is seen that the lymphatics in the cephalic half are more advanced on the left than on the right.

Vessels of sufficient size may be injected centrad with starch or plaster-of-Paris. It is not necessary to tie the cannula in place; simply pressing upon it with the fingers is sufficient. The insertion of the cannula is greatly facilitated by first inserting a beaded bristle into the lymphatic, then by raising the bristle the cut in the vessel may be seen. Where the vessels are too small to be seen, very successful injections may be made by the puncture method. That is, a hypodermic cannula is connected with a syringe or a constant-pressure apparatus, and inserted where lymphatics are supposed to be. The cannula is forced in as in ordinary hypodermic injections, and the mass allowed to flow or it is forced in. If the attempt is successful, the fine network and collecting trunks of a limited area will be injected. The toes and the finger-tips of man are favorite places for injection. In animals the pads of the feet and the bare spot on the snout are good. A lymphatic gland is always easy to inject. For an injecting mass mercury was much used by the older anatomists. Colored gelatin was also used and is now much more employed than mercury as it flows readily through the lymph glands. An excellent gelatin mass is Hoyer's chrome yellow: dry gelatin, 15 gm.; water, 75 c.c. After the gelatin is softened it is melted over a water-bath and heated to 80° C., then 75 c.c. of a cold saturated solution of bichromate of potash, heated to 80° C., is added to the gelatin; finally, 75 c.c. of a cold saturated solution of acetate of lead is heated to 80° C. and added with constant stirring. Berlin blue in gelatin is preferable for microscopic specimens (Plate XLIV. and Figs. 3293, 3300). India ink in water is also of great service, especially in embryos.[10]

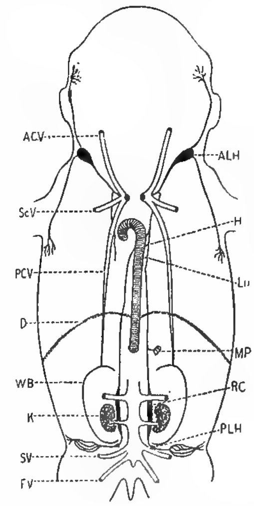


FIG. 3309.—Diagram of the Lymphatic System in the Embryo Pig 30 Mm. Long. × 2. (Sabin.) *MP*, Mesenteric plexus; *RE*, receptaculum chyli (chylocyst). The other letters as in Fig. 3307. It will be seen that in this figure the chylocyst is double, and that the thoracic duct is also double nearly to its termination. In this stage the caudal lymph sacs have lost their connection with the vein, and from now on the only connection with the vascular system is through the thoracic duct as in the adult.

The puncture method was used by Hunter, Mascagni, and Cruikshank. Cruikshank, in his "Anatomy of the Absorbing Vessels" (1790), p. 44, says: "I have sometimes injected the lacteals from punctures made by the side of the veins where I knew they must be, though they were then invisible to the naked eye." He also injected the lymphatic glands by puncture.

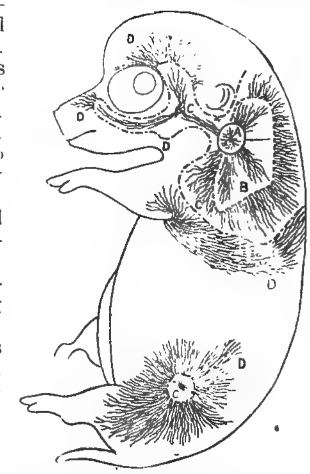


FIG. 3310. — Composite Picture of the Spreading of the Superficial Lymphatics in the Embryo Pig. (Sabin.) *A*, Area of lymphatics in a pig 18 mm. long; *B*, area in a pig 20 mm.; *C*, area in a pig 30 mm. long, *D*, area in a pig of 40 mm. long. In the stages shown there are no lymphatics beyond the outlines indicated.

Young animals are best for studying the lymphatics, and the leaner the animal the better. For investigating the embryology of the lymphatics, embryos in which the heart is still beating are best. After the embryos are cold they cannot be satisfactorily injected (Sabin [10]). In man lymphatics have been demonstrated in organs in

the fœtus when they could not be in the adult. Mature animals are better for the lymphatics of the reproductive

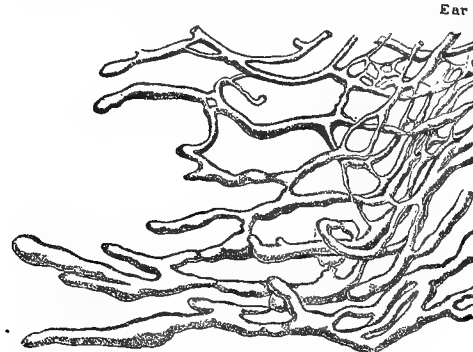


FIG. 3311.—Terminal Lymphatics of the Skin Between the Eye and Ear in a Pig 50 Mm. Long. × 11. (Sabin.)

organs; and, for the pancreas, an old man or animal is to be chosen. *Simon Henry Gage.*

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The writer wishes to express his great indebtedness to Professor Wilder for generous supplies of material for investigations in the comparative anatomy of the lymphatic system, for aid in purchasing costly works, and for hearty encouragement; to the library of the Surgeon-General's Office for the loan of rare and valuable works of reference, and, finally, to the editor for encouragement and suggestions.

In preparing the article free use has been made of the larger works on physiology: Flint's treatise, Landois and Stirling; Milne-Edwards, Leçons, etc. In human anatomy, Allen, Gray, and Quain in English; Sappey in French; Henle, Krause, Gegenbauer, and Hoffmann in German. The clinical remarks are especially complete and satisfactory in Allen; many very suggestive remarks are also made in Sappey's Atlas. In comparative anatomy the works of Owen, Gegenbaur, and Parker's translation of Wiedersheim, in English, and Milne-Edwards' Leçons, in French, are the most satisfactory. For the bibliography of the subject Mascagni, Milne-Edwards, Hoffmann, and Robin (see [5] below) are especially commendable, as is also the Index Catalogue of the Surgeon-General's library. Specific references have been made to the following:

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LYMPH NODES, DISEASES OF.—ANATOMICAL CONSIDERATIONS.—The proper appreciation of the pathological changes met with in the lymph nodes presumes a slight knowledge of the normal anatomy of these organs. They are small, bean-shaped or oval nodules which lie in the course of the lymphatic vessels and on the more protected portions of the body, as, for example, in the lateral regions of the neck, the axillæ, the inguinal regions, about the peritoneal and pleural cavities, and in the folds of the mesentery. A small depression, known as the hilus, is usually present at one portion of the node, marking the point of exit of the efferent lymphatics and the blood-vessels. The nodes lie in a soft connective tissue and are quite freely movable in the fat which often surrounds them. They are normally of a reddish-gray color, and a cross-section of a freshly removed node is usually somewhat translucent.

The nodes are surrounded by a thin, fibrous capsule containing some fat tissue and blood-vessels, and occasionally a few smooth muscle fibres. The capsule sends processes into the node which are known as trabeculæ. The capsule and the trabeculæ send off fine connective-tissue fibres into the substance of the node, forming a delicate network in the meshes of which lie the leucocytes forming the parenchyma of the organ. These cells are chiefly of the variety known as lymphocytes, which possess a single large spherical nucleus and a relatively small amount of cell body.

The masses of lymphocytes near the periphery of the node are collected into nodules known as the follicles or secondary lymph nodules. They are surrounded by a lymph sinus, derived from the division of the afferent lymphatics into an anastomosing network of spaces lined with flattened endothelium. In the centre of the follicles a lighter area can often be seen in stained sections, where the cells are slightly larger than in the periphery of the nodule and often show karyokinetic figures. The lymphocytes are formed in these germinal centres, as they are called, and pass from them to the periphery of the nodule, from which they are set free in the lymph stream of the sinus.

In the centre of the lymph nodes the arrangement of the lymphocytes is somewhat different. They do not lie in masses as in the cortical nodules, but are suspended in strands in the connective-tissue network lying between the trabeculæ, and are called medullary cords. Each cord is surrounded by a lymph sinus which separates it from the trabeculæ.

The lymph sinuses are formed from the afferent lymphatics, some of which enter the node at the sinus, others through the capsule. They pass to the periphery of the node and break up there into an anastomosing series of vessels which pass inward and surround the follicles and the medullary cords, and finally reunite to form the efferent lymphatics and pass out at the hilus. The lymph sinuses so formed are lined with flattened endothelium.

The blood-vessels enter chiefly at the hilus and are distributed first to the medullary cords and then to the secondary nodules.

Reticular tissue containing lymphocytes is not confined to the lymph nodes, but is found in the organs and especially in the mucous membrane of the digestive tract. The tonsils and crypts in the tongue, the solitary and agminate follicles of the intestine are examples of such collections. The structure of these deposits of lymphoid tissue varies from that of the lymph nodes. The development of lymph sinuses and germinal centres is much less complete than in the nodes. The lymphocytes are also not wholly carried off in the lymph circulation, but many of them wander out through the epithelial layer covering these collections of lymphoid tissue and enter the digestive tract.

The agents which incite pathological changes in lymph nodes are as a rule carried in the lymphatics to the node and first enter the lymph sinuses at the periphery of the node. Coarser particles of foreign matter, such as dust or soot, are often deposited in this portion of the node, and are taken up by the phagocytic endothelial cells of the sinus. The same is true of the cells of tumors which are found first in the periphery of the node where they occupy the sinuses. The effects of bacterial poisons are often most marked in the peripheral portions, though the bacteria are usually caught in the filters of the nodules or

medullary cords. Thus, tuberculous foci generally begin near the centre of the node and may leave the peripheral portions in a more or less normal state.

THE PATHOLOGICAL CHANGES IN LYMPH NODES.—*Pigmentation.* The pigment which is most frequently found in lymph nodes is derived from soot or coal dust. Silicious material inhaled by stone-cutters or grinders may also be transported to the bronchial lymph nodes. Deposits of iron oxide are found in the nodes of iron workers. The pigment may also be derived from the substances used in tattooing, which are chiefly India ink and vermilion. Finally, the pigment may arise in the body from the destruction of the red blood corpuscles, either following hemorrhage or produced by parasites, such as the plasmodium malariæ. The brown pigment which colors the skin and mucous membranes of those suffering from Addison's disease, may also be carried to the lymph nodes.

The pigment collects first in the lymph sinuses at the periphery of the node, being carried thither either by the lymph stream or by phagocytes. It may remain in this position either in the meshes of the fibrous reticulum or in the endothelial cells lying in the sinus. If the amount of pigment be very large, it is finally carried to all portions of the node and fills the nodules and the lymph cords.

A small mount of pigment may not cause any change in the structure of the node, but large quantities induce a chronic hyperplasia of the fibrous tissue which may result in a more or less complete destruction of the cells and the reticulum of the node, and their replacement by dense pigmented connective tissue. This chronic inflammation may involve the periglandular structures and give rise to dense connective-tissue masses about the node. Such nodes are of course functionless.

Atrophy. The lymph nodes of children are larger than those of adults, so that a slight atrophy of these structures takes place during life. In old age a more complete atrophy, with a diminution in the number of lymphocytes and thickening of the fibrous tissue of the node, is a regular occurrence. The node may be reduced to a mere shell, the centre of which is filled with fat tissue; or it may be small and hard and the fat tissue lie about it. Such nodes are paler than normal owing to the increase in the amount of connective tissue and to a diminution in the blood supply.

Amyloid degeneration of the reticulum and of the walls of the blood-vessels may appear in the lymph nodes as a part of a general amyloid degeneration of the organs of the body following prolonged suppuration, tuberculosis, or syphilis, or it may be limited to the nodes. In the

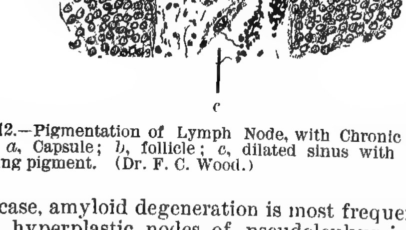


FIG. 3312.—Pigmentation of Lymph Node, with Chronic Inflammation. *a*, Capsule; *b*, follicle; *c*, dilated sinus with phagocytes carrying pigment. (Dr. F. C. Wood.)

latter case, amyloid degeneration is most frequently seen in the hyperplastic nodes of pseudoleukæmia, and in chronic or tuberculous inflammation. In advanced cases the fibres of the reticulum may become greatly swollen so as to cause the parenchyma of the node to undergo atrophy. Under such circumstances the node is hard and transparent and gives a mahogany brown when treated with tincture of iodine. Sections stained with methyl violet or thionin show the metachromatic staining characteristic of amyloid in the other portions of the body.

Hyaline degeneration of the walls of the vessels and the reticulum is occasionally seen in tuberculous or carcinomatous nodes or in old age.

Fatty degeneration is seen chiefly in the lymphocytes in connection with acute inflammation of the lymph nodes.

Fatty infiltration of the nodes is occasionally seen in obese persons, and may follow the atrophy resulting from chronic inflammation or old age.

Calcification of the nodes is seen chiefly in old tuberculous or suppurative lesions where the lime salts are deposited in the necrotic areas, but occasionally carcinomatous nodes will be found to be calcified, especially in slow-growing scirrhous carcinomata of the breast, when the axillary nodes have been invaded for a long time and degeneration has taken place in the tissue of the new growth.

Animal parasites have been found in the lymph nodes in rare cases. The embryos and adult worms of the filaria sanguinis hominis have been seen, and also the embryos of the trichina spiralis. Cysticercus and the echinococcus embryos have also been seen.

Acute Lymphadenitis. Acute inflammation of the lymph nodes is due to the presence either of micro-organisms or of their toxins. In these conditions the lymph nodes are enlarged and contain a considerable amount of serum. The capsule is distended and the blood-vessels are strongly injected. The color of the node under these conditions is a much darker red than normal. When the condition is advanced, the node softens and the softened tissue can easily be scraped from the cut surface. According to the microscopical changes which take place lymphadenitis may be divided into the hyperplastic and the exudative forms. In the hyperplastic form the changes are largely due to a proliferation of the cellular elements of the follicles, of the endothelial cells of the sinuses, and of the connective-tissue cells of the node. The endothelial cells, especially in typhoid fever, can often be found lying free in the sinuses or attached to the trabeculæ and very much swollen. The germ centres may be large and may show numerous mitoses in the early stages of the disease. Later, necrosis of the hyperplastic tissue is frequently seen and the cells cease to take any stain. In other cases the inflammation is distinctly suppurative, and in addition to the hyperplastic changes there are present lymphocytes and leucocytes from the circulation, together with hemorrhages from the blood-vessels. The tissues in the centre of the node soften, break down, and form, in this way, larger or smaller abscesses.

In very severe infections the inflammation takes on a hemorrhagic character, and the sinus may be filled with blood and a fibrin network which may finally extend between the necrosed cells of the follicles. The diphtheria bacillus is usually the inciting agent in the production of the hemorrhagic type of acute lymphadenitis, though the typhoid and anthrax bacilli may act in a similar manner. The bacillus of plague has a like action on the lymph nodes, and the nodes invaded by this organism are quite constantly the site of extensive hemorrhages, due to the necrosis of the walls of the blood-vessels produced by the toxin of this bacillus.

Very frequently the process does not remain confined to the node, but extends to the perinodular tissues, forming a periadenitis. When the process is confined to the nodes, healing may take place by resorption of the contents of the necrotic areas, and repair by the production of fibrous tissue; or, if these areas are of considerable extent, it may take place by absorption of the fluid and encapsulation of the dry mass by fibrous tissue. The débris remaining often undergoes a final process of calcification.

Chronic Lymphadenitis. This condition is characterized by chronic hyperplasia of the various elements of the node. It may be seen in conditions in which the

Lymph Nodes.

node is subjected to long-continued irritation, either by bacteria, or by toxic substances—the product of the bacteria or of the metabolism of malignant tumors,—or, finally, by the mechanical irritation of particles of soot or dust which have been transported to the lymph nodes. The general structure of the lymph node is retained. The lymph sinuses are filled by the formed elements resulting from the hyperplasia of the endothelial cells. The germ centres are often better marked than in normal lymph nodes, and in case the process continues for some time a great increase of the fibrous tissue takes place.

Tuberculous Inflammation. The tuberculous inflammation may occur in single, isolated lymph nodes, or in small groups, or may be diffused through all the lymph nodes of the body. The macroscopical appearance of a node which is only slightly involved may not furnish any clew to the changes which have taken place. When the disease is advanced to a certain extent, the node will show on cut section small, opaque, white areas, a little paler than the surrounding lymphoid tissue. In advanced forms, when a large amount of degeneration is present, the disease is easily recognizable by gross examination.

This type of inflammation is caused by the presence of tubercle bacilli in the lymph nodes, brought in a vast majority of instances by the lymph stream and only rarely through the blood-vessels.

Several types of tuberculous inflammation can be distinguished. In the first, one finds many small tuberculous nodules which are situated in the lymph nodules at the periphery of the node and in the lymph cords. The tuberculous changes begin by a proliferation of the flat endothelial and connective-tissue cells of the reticulum. In the centres of these nodules cheesy degeneration often makes its appearance, and on the borders of the cheesy areas are often to be found large and small giant cells.

Another type of alteration in the lymph nodes produced by the tubercle bacillus is a diffuse hyperplasia of the flat cells of the tissues with the production of more or less necrosis. In early cases there may be no necrosis and no giant cells. In later cases the necrosis may extend to the capsule and the node may contain no giant cells and no remnants of the original structure. Such nodes may soften and break down, and then discharge their contents into the tissues or into an organ near by, such as the lung or the bronchi; or lime salts may be deposited in the cheesy matter and the whole node become calcified. The bacilli in these cases disappear from the node. In the acute cases the bacilli are found in the cheesy masses and in the giant cells, which often contain large numbers.

In those nodes in which the amount of infection is small the lesions of simple inflammation will be found in the periphery of the nodes and around the tubercles. The cells of the follicles and the sinuses will be increased in size, and there are often more or less swelling of the endothelial cells and a proliferation of the cells of the reticulum.

The lymph nodes, which are most frequently attacked by tuberculous inflammation, are those of the lateral aspects of the neck, especially the submaxillary nodes. The portal of entry for the infection may be tuberculous changes in the tonsillar tissues, tuberculous otitis, or a tuberculosis of the nose, or the bacilli may enter through carious teeth. It is possible also that tubercle bacilli may pass through the intact mucous membranes of the mouth and the pharynx.

The bronchial nodes come next in order in frequency of infection, and in tuberculous children the occurrence of tubercles in these nodes has been noted in seventy-five per cent. of the cases dying in hospitals. The infection is carried through the lungs to the bronchial nodes, or in rarer cases from tuberculous lesions of the bones of the thorax. The mesenteric nodes are frequently found to be tuberculous in children in whom the bronchial nodes have also become involved. Direct infection from the intestine, without other tuberculous lesions in the body, is probably a rare occurrence.

Scrofulous Enlargement. The chronic enlargement of the lymph nodes in poorly nourished children, designated clinically as "scrofulous," is still of undetermined nature. While it is true that tubercle bacilli can be demonstrated in a considerable proportion of such nodes, yet it is also true that they are not constantly present. Some observers assume that we have two separate conditions, one a mild tuberculous infection, the other a chronic simple inflammation of the nodes, due to other bacteria than the tubercle bacillus. It has also been suggested that the chronic nature of the process is due to the low virulence of the tubercle bacillus. Our present knowledge of the variability in virulence of the tubercle bacillus, however, is so incomplete that definite conclusions cannot be deduced and the question must be regarded as still open for investigation.

FIG. 3313. A Portion of a Tubercle in a Lymph Node. In the centre is a giant cell surrounded by necrotic material; beyond this a layer of endothelial cells; and at the periphery the remnants of one of the follicles of the node. (Dr. F. C. Wood.)

Syphilitic Lymphadenitis. The changes produced in the lymph nodes by the poison of syphilis vary according to the stage of the disease. During the existence of the initial lesion the neighboring lymph nodes often show a simple acute inflammation which may go on to suppuration and the formation of a bubo, especially if the primary sore is not kept clean.

During the secondary period the nodes swell and become hard, but remain perfectly movable. The increase in size is due chiefly to an increase in the number of lymphocytes; but there may also be an increase in the endothelial and connective-tissue cells, and an infiltration of the walls of the vessels with leucocytes. If the patient is treated with mercury, the cells undergo fatty degeneration and absorption and the node returns to a normal condition. If, however, the inflammation has persisted for any length of time, the fibrous changes are likely to be permanent.

Gummata may develop in the lymph nodes in tertiary syphilis, but this is rare and as a rule involves only single nodes. The changes which take place resemble morphologically those produced by the tubercle bacillus. No bacilli can be found, however; giant cells are not usually so abundant, and the necrotic areas tend to dry up rather than to soften and break down.

Tumor Formation in Lymph Nodes. The classification of the tumors found in lymph nodes is still incomplete. The source of the difficulty lies in the fact that certain chronic hyperplasias of the nodes seem to depend on infectious processes, and others, of a closely similar morphology, seem to be independent of such an inciting agent. Five types of progressive, tumor-like enlargement of the lymph nodes can be distinguished in our present state of knowledge.

1. Lymphadenoma—a progressive increase in the lymph nodes of the body accompanied by anæmia. This condition is known clinically as Hodgkin's disease or pseudoleukæmia. A group of nodes such as those in the cervical region may first be attacked, and the process may extend later to other groups; or the enlargement may begin simultaneously in all parts of the body. The enlargement is a simple hyperplasia, the structure of the nodes being in general retained, and the morphological distinctions between the germ centres, the follicles, and the sinuses are not entirely obliterated until the disease is far advanced. Nodes so affected do not, as a rule, break through their capsules, but remain discrete. When examined in a fresh condition, these nodes are found to be harder than

normal and the cut surface is pale as compared to the gray color of a normal node. There is no tendency to necrosis.

There may be hyperplasia of the lymph nodules in the organs, such as the liver, spleen, and kidney, and in the walls of the intestine; but diffuse infiltration of the viscera with lymphocytes is not seen. The changes in the blood are those of a severe anæmia of a chlorotic type, without increase in the number of leucocytes. Pinkus has recently claimed that all cases of Hodgkin's disease show a relative lymphocytosis, but this has not been proven and the cases which the writer has been able to observe have shown no such change. Death is usually due to some intercurrent condition or to the mechanical action of the tumors—as, for example, compression of the trachea.

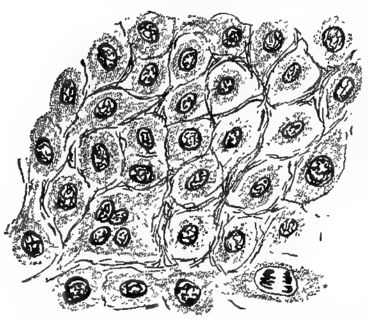


FIG. 3314.—Lympho-Sarcoma. The intercellular connective tissue is well developed in distinction from that in small round-cell sarcoma. (Dr. F. C. Wood.)

2. Tuberculous hyperplasia of a smaller or larger number of nodes. A number of cases have been described which ran a clinical course exactly similar to that of Hodgkin's disease, but showed on autopsy either nodes with a large amount of necrosis and tubercle tissue, or a simple hyperplasia of the nodes without any morphological tubercles in these nodes. Tubercle bacilli can be demonstrated by staining or by animal inoculations. The blood of such cases shows the anæmia characteristic of Hodgkin's disease. Pinkus claims, however, that a relative lymphocytosis is not present in the tuberculous cases.

3. Hyperplasia of the lymph nodes in connection with either lymphatic or myelogenous leukæmia. Such hyperplasia is of more or less constant occurrence, especially in the lymphatic types, but the enlargement rarely reaches the extent seen in Hodgkin's disease. The examination of the blood reveals the nature of the disease. The nodes may be simply hyperplastic, with a great increase in the number of lymphocytes and a loss of the characteristic morphology, as is seen in lymphatic leukæmia, or the nodes may show alterations known as myeloid degeneration in cases of myelogenous leukæmia. This change consists in the appearance, in the lymph node, of structures found under normal conditions in the bone marrow only. These are the myelocytes or characteristic cells of the marrow, with the granulations proper to the three types which are found in that situation. These myelocytes are deposited in the node and there proliferate, forming small masses of a structure strikingly different from that of normal lymphoid tissue with its small non-granular cells. The nodes in the acute forms of lymphatic leukæmia often show hemorrhagic areas; these are less common in the chronic leukæmias.

4. Lymphosarcoma. This form of primary new growth arising in lymph nodes is distinguished from the tumors formed in Hodgkin's disease by the fact that it does not retain the normal morphology of the node but rapidly proliferates and breaks through the capsule to infiltrate the surrounding tissues and to form metastases in other portions of the body. The tumors show a marked tendency to degenerate and soften at their centres. Another point of differentiation between lymphosarcoma and the hyperplasias of the lymph nodes is in the large amount of connective-tissue reticulum between the cells of the former. This also aids in differentiating these tumors from the small round-celled sarcomata in which the connective-tissue reticulum is small in amount, or entirely absent in portions of the growth.

The lymphosarcomata may involve only a group of nodes, or a number of nodes in different portions of the body may enlarge simultaneously and by their metastases give rise to a general sarcomatosis with a diffuse infiltration of the tissues of the body, especially those of the liver and kidney.

5. Sarcoma. Primary sarcomata of the lymph nodes are rare. They must not be confused with the lymphosarcomata which usually involve a number of nodes simultaneously and diffusely infiltrate the organs of the body. The true sarcomata are confined as a rule to a single node, soon break through the capsule, and form nodular metastases by the transfer of tumor particles through the medium of the blood current, but they do not as a rule involve other lymph nodes.

The types of sarcomata which have been described as arising from lymph nodes are: spindle-celled sarcoma, with more or less fibrous tissue; melanosarcoma; angiosarcoma; and round-celled sarcoma; the last being often indistinguishable from the true lymphosarcoma. Ziegler figures an alveolar sarcoma of a lymph node.

Endothelial tumors have been described as arising in lymph nodes, but, inasmuch as the morphology is always suggestive of carcinoma, it is probable that the cases reported have been due to the invasion of a node from some internal carcinoma whose existence was not observed.

The writer has in his possession two tumors from the region of the neck, one of which is morphologically an endothelioma of the cylindromatous type, the other an alveolar sarcoma derived apparently from the large endothelial cells of the trabeculæ. It is possible, however, that both of these growths are congenital remains from some of the glandular structures in the neck, and that the lymphoid tissue which they contain is merely the lymphoid tissue so often seen about the congenital cysts and ducts of the cervical region.

Secondary invasion of the lymph nodes by sarcomata is rare. The tumor particles reach the nodes through the blood-vessels as a rule, and spread diffusely throughout the lymphoid tissue. Such metastases occur most frequently in certain types of sarcoma, notably the small round-celled and the melanotic forms. In central sarcomata of the bone the regional lymph nodes are frequently invaded.

6. Carcinoma. Carcinoma of the lymph nodes is always secondary to a tumor of such portions of the body as contain epithelium. Such secondary invasion of lymph nodes by the cells of epithelial new growths takes place through the afferent lymphatics; and the cells, therefore, are first deposited in the lymph vessels and the sinuses at the periphery of the node. In very early cases the cells of the tumor may be confined to these points and not invade the follicles or cords. The tumor cells may attach themselves to the walls of the lymphatics and grow over the surface of the endothelial cells lining these vessels, giving rise to an appearance which has been erroneously interpreted as a new formation of carcinoma cells from

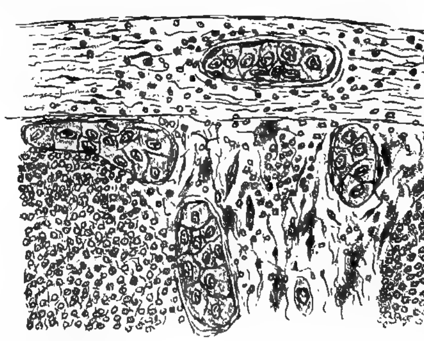


FIG. 3315.—Invasion of a Lymph Node with the Cells of a Carcinoma. The peripheral lymphatics and a portion only of the sinus are involved. (Dr. F. C. Wood.)

the endothelial cells of the vessel walls. The sinuses may be partially or wholly filled with the large cells of the new growth, which can be distinguished from the sinus endothelium by the more regular outline of the cell and the abundant chromatin of the nucleus. As the growth of the tumor cells continues the entire node may be replaced by them, but usually, before this takes place, there is a considerable increase in the amount of connective tissue present. Degenerative changes may take place in the tumor cells with necrosis of the tissue and softening of the centre of the node. Occasionally these softened nodes become infected and give rise to a suppurative periadenitis.

The presence of a malignant epithelial growth usually causes a slight hyperplasia of the neighboring lymph nodes, even though the tumor is not infected with micro-organisms or ulcerated. These changes are confined chiefly to the peripheral sinuses and produce an hyperplasia of the sinus endothelium which may be mistaken by a careless observer for an invasion of the tumor cells. The germ centres of the follicles are also more prominent in these nodes than in those under normal conditions. Apparently the metabolic products of the tumor have the power of slightly irritating the lymph nodes through which they are filtered.

Lymph nodes invaded by the cells of a carcinoma can usually be diagnosed by gross inspection. The node is hard, and on section the areas involved are much paler than the normal node and more opaque; but occasionally nodes will be seen which, though invaded by the new growth, do not differ sufficiently from the normal to allow of a diagnosis by inspection, and recourse must then be had to microscopic examination. Nodes invaded by a sarcomatous new growth cannot usually be distinguished from the normal except by their size. An exception is seen when the sarcoma is of a melanotic type; such nodes may be almost black from the pigment of the tumor.

Francis Carter Wood.

LYMPHOMA.—This term has been used indiscriminately to indicate any enlargement of the lymphadenoid structures of the body, without regard for the true nature of the enlargement or its etiology. Most commonly it is applied in general medical literature to the generalized lymphadenoid hyperplasia associated with leukæmia and pseudoleukæmia (often distinguished as "malignant lymphoma"), or to the more localized glandular enlargements of lymphosarcoma, benign lymphatic hyperplasia, and primitive splenomegaly; yet it is by no means infrequently that "syphilitic lymphoma," "scrofulous lymphoma," or "acute lymphoma," is referred to under this title. In the proper use of the word, it should be limited to apply only to true neoplasms that reproduce the structure of lymphadenoid tissue. These tumors would be benign, since malignant tumors of similar nature would come, in the usual classification, under sarcoma, specified as "lymphosarcoma." A new growth of lymphadenoid tissue of infectious origin, whether the etiology is known or not, should not be called lymphoma. The confused condition of the classification of the various lymphatic enlargements is attributable to the ambiguous structure of the growth and the difficulty of distinguishing even those of known etiology from one another. That the term lymphoma continues to be used in this irregular way is probably because benign tumors reproducing lymph-gland structures, that are distinctly neoplasms, are so rare. Such a case has been described by Le Count,[1] but there seem to be few other instances in the literature, probably because they have not been recognized, rather than that they do not occur. Le Count's case is described as follows:

In section the fresh specimen is light reddish, its surface studded with areas resembling closely the Malpighian bodies of the spleen. The growth is encapsulated, has no coarse trabeculæ, is not very vascular. Histologically it is characterized by reproducing quite closely, but with some differences, the structure of a normal gland. There are many nodes with an area of large pale cells, of endothelial type, which are usually central and located at or near the point where an arteriole breaks into capillaries. Surrounding this are quite regular rows of small lymphoid cells. The tissue between the nodes is loose, consisting of a fine, non-nucleated reticulum, supporting small lymphoid cells.

Because of its rarity, and its eminently benign course, such a true lymphoma is merely of scientific interest. Of much more importance are the lymph-gland enlargements associated with leukæmia and pseudoleukæmia, which are what is commonly designated by the term lymphoma. While leukæmia is a fairly distinct condition, as well pathologically as clinically, the reverse is true of pseudoleukæmia, and to obtain any clear picture of its anatomical basis is almost hopeless. If we admit, however, that by pseudoleukæmia or Hodgkin's disease is understood a fairly definite symptom complex, characterized by general lymphadenoid hyperplasia, anæmia without leucocytic increase, and a course always downward, and accept the view that these conditions may be produced by a variety of etiological factors, the situation is somewhat simplified. Then we can place on one hand those cases which are manifestly infectious, generally tuberculous, as has been shown by Sternberg,[2] Crowder,[3] and others. This leaves a group in which the glandular enlargement is much more like a tumor growth, both in structure and in absence of apparent cause. Two types of enlargement may be distinguished. In one the process resembles that of a malignant tumor, both macroscopically and microscopically. In the other, the change retains the essential features of benign growth, although multiple, and this benign enlargement corresponds anatomically to the localized enlargement of one or a small group of glands that is observed occasionally remaining for long periods without the accompanying manifestations of Hodgkin's disease, which local glandular enlargement is quite generally known among surgeons as lymphadenoma. This process then simulates a true benign tumor growth, and it is to this that the term lymphadenoma* is best applied, to distinguish it from the malignant type of lymphadenoid growth, to which the term *lymphosarcoma* should be restricted.

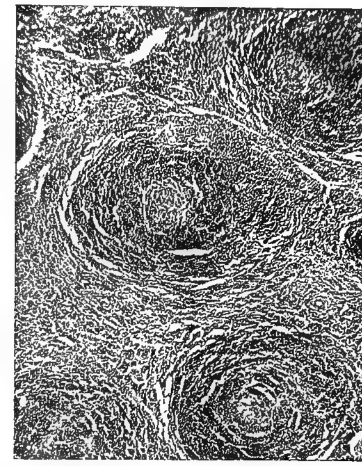


FIG. 3316.—True Lymphoma. Photograph of section showing lymph nodes and internodal tissue. Slightly magnified. (Le Count.)

The use of the termination *oma*, placing this condition among the tumors, is tentative, for there is much reason to believe that eventually such enlargements will all be found to be infectious; but as this is equally true in the case of many other tumors, such terminology is justifiable. It must be admitted, however, that the most substantial reason for using such a term as lymphadenoma at all lies in the fact that such usage is general, even by acknowledged authorities, and the function of such an article as this is rather to record what is than to suggest what should be.

* Other names found in use to indicate the general glandular enlargement of Hodgkin's disease are: lymphadenosis, lymphosarcoma, lymphoma, malignant lymphoma, pseudoleukæmia, anæmia lymphatica, adénie, lymphadénie. Since these terms are in many instances contradictory, it is evident how loose the ideas and nomenclature on this subject really are.

Lymphadenoma, as above defined, is a process of enlargement of lymph glands which is remarkable in affecting several glands simultaneously, or in rapid succession. Usually the growth is limited to one group at first, to involve the others later, or it may appear in widely separated places at the same time. Sometimes the usually recognized groups of glands alone are involved, but often every portion of lymphadenoid tissue in the body is affected, and microscopic structures may enlarge to considerable swellings. It is this peculiar diffuseness of the process that distinguishes it from any ordinary tumor growth and makes the infectious origin seem so probable.

FIG. 3317.—Photograph of Centre of a Lymphoma Node, Showing the Pale Germinal Centre and the Rows of Lymphoblasts. (Le Count.)

When the growth is examined closely it is found that even in the largest masses the individuality of the component glands has not been lost by fusion; each preserves its own capsule, although they may adhere closely to each other. The separate glands may reach the size of a hen's egg, although usually few are larger than a hickory nut. The groups of glands in the cervical, axillary, mediastinal, and retroperitoneal regions often form huge tumors, of irregular outline and nodular surface. In consistence the glands are about as soft as normal kidney tissue. The external surface is pale, and the cut surface a pale pink. In some glands the cut surface shows almost no apparent structure, it is alike from centre to margin; in other cases, a considerable growth of connective tissue is seen, dividing the gland into irregular lobules. The gland is not pultaceous, and areas of necrosis and hemorrhage are rarely seen. Suppuration is uncommon, and almost always due, when present, to erosion of some surface. If the spleen is enlarged, as it usually is, it seems that the follicles are affected chiefly, and in a way quite like the glands. The tonsils and intestinal lymph follicles project, and may form tumors similar in structure to the glands.

Microscopically it is seen that a great increase in all the cellular elements of the gland has taken place, disorderly and not constant in proportion or arrangement. The arrangement of follicles and sinuses is quite lost. Both the large endothelial and small lymphoid cells are increased, sometimes one out of proportion, sometimes the other. Often there is also a distinct increase in fibrous tissue, generally in strands extending from the capsule toward the centre. Frequently large cells are seen, sometimes with a single enormous, irregularly shaped, deeply staining nucleus; large cells with from three to a dozen nuclei are also abundant in some cases. Phagocytic endothelial cells containing blood pigment and mononuclear cells may also be found. As a rule the more extensive the process the more the structure diverges from that of the normal gland; in the circumscribed, simple lymphadenomata, without constitutional symptoms, the growth may be quite similar to the true lymphoma.

Lymphadenoma differs from the lymphosarcoma grossly in that the gland capsule limits the growth, surrounding tissues are not invaded, the process more often affects lymph structures throughout the body without involving any other tissue, there is never a single large mass of tumor tissue, while it may be soft yet it does not yield a milky fluid from the cut surface, and necrosis and hemorrhage are seldom seen. Microscopically the sarcoma shows a far more atypical structure; the round cells are usually almost alone, stroma formation is slight, and the endothelium-like formations are generally absent; hemorrhages, necrosis, and karyokinesis are much more abundant. As can be easily understood, it is at times very difficult, perhaps impossible, to make any distinction between the benign and the malignant forms of growth.

Tuberculous adenitis usually offers no difficulty because of the characteristic caseation, the typical zone arrangement, and the giant cells; but quite a number of cases have been described in which with a gross and minute structure corresponding to lymphadenoma, and without any evidences of tuberculosis, staining and inoculation have revealed tubercle bacilli. This fact leaves the neoplastic nature of lymphadenoma always in doubt.

Leukæmic glands offer to the naked eye no essential differences from those of lymphadenoma, and some authorities, as Ziegler, speak of a "leukæmic lymphadenoma," and a "pseudoleukæmic lymphadenoma." The fundamental difference in the process is that in leukæmia the new-formed cells leave the gland to form leucocytes, while they remain within the reticulum in lymphadenoma. Usually the structure is more atypical in leukæmia, the round cells predominating, but the only visible difference may be the presence of abundant leucocytes in the blood of sectioned vessels. Grossly the glands show few differences, although they are likely to be softer and exude milky fluid on section in leukæmia; the lymphoid accumulations in the viscera are of course quite characteristic.

The etiology is quite unknown, as in the case of a true tumor, but that the growth is of infectious origin seems most probable in view of the simultaneous involvement of so many lymph glands, and the difficulty of distinguishing it from the generalized tuberculous adenitis that has been so frequently observed in recent years. In favor of its being a true tumor are mentioned its frequent change to malignancy and the narrow demarcation from lymphosarcoma, the abnormal nuclear forms seen in the large cells, and the progressive course. Various organisms have been described, but too inconstantly to be entitled to consideration. The growth occurs oftenest in young adults, particularly males, without predisposing causes being recognizable, as a rule.

The course is almost inevitably downward in the cases of generalized glandular enlargements, *i.e.*, Hodgkin's disease. In the cases of localized glandular tumors the growth may be very slow, and after reaching a certain size, become stationary. It has been said that they may cicatrize and heal spontaneously, but considering the difficulty in distinguishing them clinically from tuberculous glands, such statements are open to question.

H. Gideon Wells.

[1] E. R. Le Count: Lymphoma, a Benign Tumor Representing a Lymph Gland in Structure. Journal of Experimental Medicine, iv., 559, 1899.
[2] Sternberg: Zeitschrift für Heilkunde, xix., 1898.
[3] T. R. Crowder: New York Medical Journal, 1899.

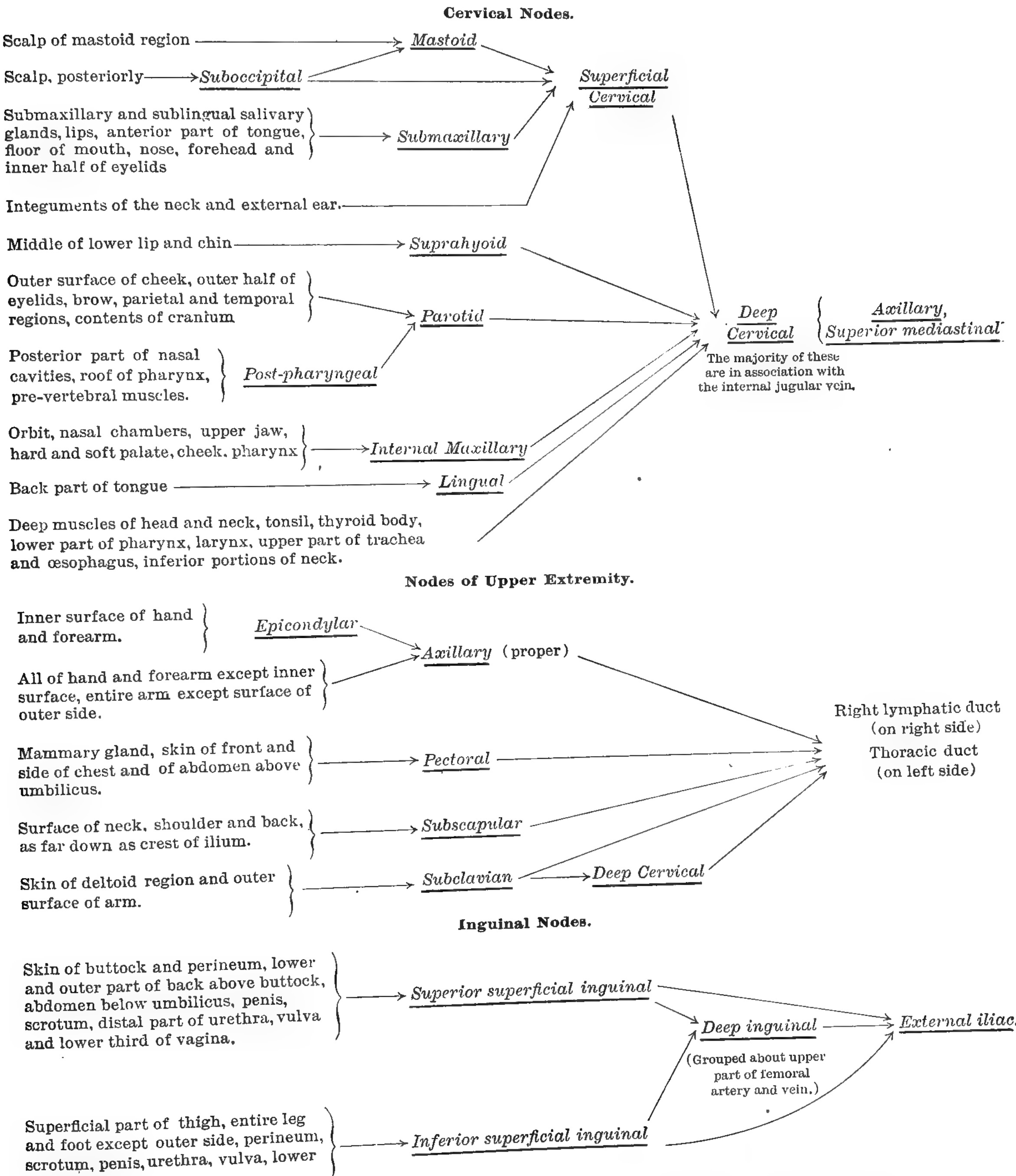
LYMPH VESSELS AND NODES, SURGICAL AFFECTIONS OF.—ANATOMY AND PHYSIOLOGY.—In order to make the subject of this article clear, the writer desires to recur for a few moments to the anatomy and physiology of the lymphatic system. This system comprises the lymphatic vessels or channels and the nodes or ganglions which are commonly spoken of as glands. The vessels are analogous to veins in their structure. They

are distributed almost universally throughout the body. There are, however, three principal groups, viz., those which ramify in the subcutaneous cellular tissue, those which accompany the great vessels, and those in association with the various internal organs. The first and second of these groups are of special interest to the surgeon, whilst the third, being largely inaccessible during life, will not here be considered.

The nodes (or glands) are collections of specially arranged lymphoid tissue situated in the course of the lymphatic vessels. They are in some instances solitary, but more frequently arranged in groups. The more important groups are in close proximity to the great blood-vessels. The nodes are surrounded by loose connective tissue, and in the case of the extremities they are found chiefly at the flexures of the joints.

The lymphatic system is sometimes spoken of as the absorbent system, inasmuch as one of its chief functions

DIAGRAMS SHOWING THE CHIEF GROUPS OF EXTERNAL LYMPH NODES, AND THE SOURCES FROM WHICH THEIR LYMPH SUPPLY COMES. (THE NAMES OF THE NODES ARE PRINTED IN ITALICS.)



is to take up the fluids from the tissues and carry them to the venous circulation. This function is shared by the veins, which also act as absorbents to a considerable extent. For our present purpose we need not go into the theories of the function of the lymphatic nodes further than to say that they act as filters in removing from the lymph current extraneous matters which may have gained access to the system.

In the broadest sense, it may be said that all of the diseases of the lymph nodes are the result of infection either local or general. Whether the presence of micro-organisms in the gland is essential to give rise to the different conditions, or whether their products may also be factors in producing the changes which we recognize, has not been determined. Nor does the fact that the etiology of certain affections is still unknown modify the foregoing statement, because the analogy with those diseases which are understood is sufficiently close to warrant this assumption.

In order to form an intelligent idea of the sources from which any diseased lymph gland has received its poison, it is necessary to understand the areas in which originate the lymphatic vessels emptying into this gland. As above mentioned, there is a set of lymphatics in the subcutaneous tissue, and another in association with the great blood-vessels. The former is called the superficial set, and the latter the deep set. The number of lymph nodes in the body is estimated at from five hundred to seven hundred. The chief groups of lymph nodes, and the sources from which their lymph supply comes, are shown in the preceding diagrams.

Affections of the Lymph Vessels.

Injuries of the Lymph Vessels.—Injuries of the lymph vessels unaccompanied by infection heal kindly. In all operations, as well as in accidental wounds, these trunks are freely divided without in any way complicating the healing process.

The thoracic duct has been wounded in a few instances during operations involving the base of the neck on the left side, the accident being manifested by the free escape of chyle. The flow has been controlled in different cases by a tampon, by pressure forceps, and by suture. Recovery has usually followed without incident. The duct has also been ruptured in severe injuries involving the chest and abdomen. In these cases the chyle escapes into the thorax (chylothorax) or into the abdomen (chylous ascites). The symptoms of these conditions would be those of fluid in the respective cavities, the character of which could be determined only by the use of the aspirating needle. These cases are not amenable to surgical treatment. The patient usually succumbs to inanition, although recovery has been recorded. Agnew proposed, in these cases, to withhold all food for a time in order to favor the closure of the opening. During this period, it has been suggested to introduce milk directly into a vein.

Lymphangitis.—As this form of disease of the lymph vessels is discussed separately under its own title, the reader is referred, for information on the subject, to the corresponding article.

Lymphangiectasis.—The lymphatic vessels, like the veins, are occasionally the seat of dilatation, hypertrophy, and varicosity. This condition, when affecting the skin vessels, produces a soft pulpy mass, proportionate in size to the extent of the change. The most frequent sites of occurrence are on the inner surfaces of the extremities, at the flexures of joints, and about the abdomen and genitalia. The condition is usually congenital, but may be acquired from obstruction to the lymphatic circulation. When the dilatation becomes extreme, rupture may take place. This is followed by a flow of lymph, which is called *lymphorrhagia*. If the condition is marked enough to call for treatment the affected areas may be extirpated by the knife if there be no contraindication; or, in the case of an extremity, an elastic support may be worn. This condition is one of the causes of enlargement of the tongue, known as *macroglossia*, and of the lips, macrocheilia.

Lymphangioma.—When the dilatation of the lymphatic vessels is marked and circumscribed, the condition is called lymphangioma. This corresponds in every way with a venous angioma, with which, in fact, it is sometimes associated. These tumors are soft and semifluctuating, giving the same sensation to the touch as a venous angioma, from which they differ, however, in having little or no color, whereas the venous tumors are of a deep purple hue. When the venous and lymphatic dilatations are associated, the depth of the color will depend upon the extent to which the blood-vessels are involved. These tumors are congenital in their origin, although they may not develop to a prominent degree for some years.

Treatment.—These masses, when not too extensive, may be extirpated. In cases in which this treatment is not applicable, an elastic support would tend to prevent further extension of the condition. In extreme instances rupture is to be feared, and hence appropriate treatment should be adopted.

Lymphœdema.—This condition is due to a diffuse dilatation of the vessels and stasis of the lymph current. In an advanced state it is called elephantiasis Arabum. It is analogous in its results to an inflammation of the skin and subcutaneous tissues, of a very chronic type. There exist œdema and exudation of fluid in the tissues, and a great increase in the connective-tissue formation. It gives rise to elephantiasis, which in some cases reaches extreme proportions. The cause of elephantiasis is in many instances the presence of the filaria sanguinis hominis, which gives rise to lymph thrombosis and inflammation.

Other causes of lymph stasis bring about the same result, but perhaps to a less degree. The removal of the inguinal nodes, for example, has been followed by a persistent lymphœdema of the corresponding limb.

Treatment.—The use of massage, elevation of the part, and an elastic bandage comprise all that can be done in a palliative way. When these measures fail to give relief, redundant tissue may be excised in suitable cases when the genitals are affected; or the main arterial supply may be cut off by ligation when the lower extremities are involved. Both of these are severe measures, but are justifiable in extreme instances of the affection.

Affections of the Lymph Nodes.

Scrofula.—Let it be understood at the outset that the writer does not believe in the existence of a disease, or even of a "tendency," "predisposition," or "diathesis," which may properly be designated "scrofula." The term is mentioned here because it is still employed—although with rapidly decreasing frequency—in medical text-books and current medical literature. That condition of lymph glands which was formerly called "scrofula" and is to-day, to some extent, so designated, should be spoken of as "tubercle." While surgical writers with great unanimity ascribe the majority of cases of chronic enlargement of lymph glands to the presence of the tubercle bacillus, some few still hold to a distinct type of the affection for which they retain the term scrofulous. This view is highly objectionable because it tends to obscure the pathology of the disease, to divert the attention of the profession from the real cause, and hence to make the treatment empirical and impotent. It is not claimed that such glands are invariably tuberculous, but that the majority are, and that the rest are due to some *other* infection, while *none* are scrofulous.

Some writers are in the habit of using the terms "scrofula" and "tubercle" synonymously, but this is to be condemned. Much might be said in support of this view, but it is not the purpose of this chapter to deal with pathology. Suffice it to say, therefore, that whatever lacks a sound pathological basis is either to be rejected or held *sub judice* until sufficient light has been added to warrant a conclusion.

Nor is there any more justification for believing in a

"vice of constitution" which should be called scrofulous. It may be asserted with great positiveness that the local affection of the lymphatic glands which has been known as scrofula is a primary infection of the glands, usually with the bacillus of tuberculosis, and not the secondary effect of a constitutional disease. It cannot be denied that tuberculous glands are frequently, although by no means always, found in individuals who are anæmic and otherwise ill-conditioned. This relation is to be explained upon the ground that such subjects not only suffer from catarrhal and other affections that offer a ready means by which germs may gain an entrance into the system, but also possess phagocytes which, like the tissues and glands generally, are not up to the normal standard of vigor, and consequently are unable to resist effectually the invasion.

Neither the profession nor the patient will benefit by calling such a condition scrofula. The underlying causes are probably not the same in all cases. As suggestions, it may be said that affections of the mucous surfaces expose the individual to infection, inasmuch as bacteria more readily penetrate an inflamed or ulcerated membrane, while at the same time the resistance is less effectual on account of the depressing effect which such conditions have upon the system. Some persons appear to have defective blood-making organs, and hence to have impoverished blood and feeble resistance. Others have imperfect digestion and assimilation, etc.

TUBERCULOSIS.—This is by far the most important disease of lymph nodes, as it outranks in frequency all other affections combined. Under this title are included all of the glandular conditions heretofore called scrofulous. No region is exempt; every portion of the lymphatic tract is perhaps equally susceptible, but certain groups of glands are affected much more frequently than others because of their greater exposure to infections.

Frequency.—Observers have asserted that tuberculous lymph nodes exist somewhere in the body in one-third, or even a larger proportion, of all autopsies. The majority of instances are in the bronchial, mesenteric, and retroperitoneal nodes, which, as a rule, cannot be recognized during life. Of the surgical (external) forms, the cervical nodes outnumber all others in frequency, the axillary nodes stand next, and the inguinal last.

Age.—The affection is most common in the first decade of life. From this time on, the proportion of cases gradually diminishes. No age, however, is exempt.

Sex.—There is no marked disproportion of frequency in the two sexes.

Race.—The negro, as met with in this country, probably exhibits the highest degree of susceptibility to tuberculosis. The Irish immigrants seem to be more frequently affected than those who are acclimated.

Etiology.—The bacillus tuberculosis is the cause of the affection. The bacilli find their way into the tissues through abrasions of the skin or mucous membranes and are then taken up by the lymph current and carried along until arrested by the first lymph gland. It must also be admitted that the bacilli may be deposited in the nodes by the blood current, but this mode of infection is probably infrequent.

The lymph nodes of the neck are affected very much more frequently than any other group of external lymphatics. The reason for this is that these drain such an extensive area of exposed surfaces, all of which are subject to pathological conditions which permit the tubercle bacillus to penetrate the tissues.

The more important of these conditions are: eczema of the scalp, fissures of the lips, carious teeth, ulcers of the tongue and buccal surface, various affections of the tonsils, nasopharyngeal catarrh, adenoids, and suppuration of the middle ear. Of these the tonsils are probably the portal through which the bacilli enter the system in the majority of cases. The frequency of tuberculosis of the tonsils has but recently been recognized, and its importance as a means of infecting the individual appreciated.

Tuberculous disease of the nodes of the axilla and groin, the two other groups of surgical interest, occur as a result of infection passing through lesions of the upper and lower extremity respectively. Examples of the affection in these situations are rare because of the fact that the surfaces drained by these glands are—the hands excepted—well protected and not predisposed to the conditions which favor the entrance of the bacillus. Moreover, the great sources of the infection are the air, the food, and milk. If the mucous membranes of the respiratory and alimentary tracts are normal, the presence of the bacilli probably does no harm; but if abrasions exist, or even if the surface is merely inflamed, they are able to penetrate its layers, from which they are taken up, and carried along, by the lymph current. A chronic catarrh probably so reduces the normal resistance of the epithelium as to invite infection.

An important question, still unsettled, is as to whether the tuberculous infection of the glands is always the primary condition, or whether the glands are first the seat of inflammation, the result of the presence of some other micro-organism, and the tuberculous process is engrafted upon this. It is probable, however, that the disease begins in both of these ways, and, further, that a gland primarily the seat of tuberculosis frequently becomes the seat of a secondary infection. Certain it is that some of the cases appear to be examples of pure tuberculous disease, while others show a mixed or multiple infection.

The means by which other bacteria reach the lymph glands is similar to that described in speaking of tuberculous infection, namely, through lesions of the surface of the body, thence through the lymphatic vessels.

Symptoms.—The invariable result of infection of a lymph gland is enlargement; hence a gland which under normal conditions cannot be felt becomes, when diseased, palpable and frequently visible. In the purely tuberculous type the increase in size is commonly the only evidence of the disease, until softening occurs in the later stages. If the infection be due to one of the pyogenic germs, either as a primary affection or superadded to a tuberculous node, there will be, in addition to swelling, local pain, tenderness, and redness of the surface over the gland. In some cases these symptoms come on with great rapidity and marked severity, due either to the virulence of the infecting material, the dose received, or the weak resistance of the individual, or perhaps to a combination of two or all of these factors. In illustration, it may be said that a tuberculous adenitis runs a chronic course and gives rise to but mild symptoms. Adenitis due to the staphylococcus gives rise to moderately acute symptoms, while in streptococcus infection the manifestations are frequently so severe as to justify the term virulent. There is every grade of severity between these extremes. It must also be borne in mind that glands which have been enlarged for some time, but have remained quiescent, may, as the result of a fresh infection, suddenly take on acute symptoms.

A single group of glands are usually affected, especially in the early stages. Occasionally there are multiple foci of disease; particularly is this true in the neck, where it is sometimes bilateral. In the late stages the affection extends from group to group until it seems that all of the lymphatic glands on both sides of the neck are involved.

In very rare instances the whole lymphatic system has been involved.

Constitutional symptoms are usually present in proportion to the severity of the local manifestations. In the tuberculous form there may be but a slight elevation of temperature, while the suppurative cases exhibit a marked pyrexia, accompanied by the usual symptoms of fever—malaise, anorexia, headache, coated tongue, etc.; in other words, the condition is that of a septic infection.

Course.—The course of a tuberculous gland tends to destruction by liquefaction. The degenerative process may be very slow, extending over a period of months or years. The glands sometimes remain quiescent for long periods, only to take on renewed activity sooner or later. In some cases there are several attacks of acute symp-

toms, followed by recession before breaking down finally occurs.

Liquefaction is invariably followed, soon or late, by spontaneous evacuation through the skin, or other route, unless the abscess be evacuated by incision. A sinus remains which persists until all of the remaining tuberculous material is discharged, which is usually a long time.

When a number of glands are involved in the same group they may coalesce and discharge through a single tract, leaving but a single sinus; or there may be as many sinuses as there are diseased glands.

Cases which have a secondary infection superadded run a much more rapid course.

Finally, in rare instances, the breaking down of the gland is followed by absorption of the fluid, and spontaneous cure results by caseation and calcification.

Diagnosis.—The presence of enlarged lymph glands, without apparent cause, running a subacute or chronic course, especially if situated in the neck, is presumptive evidence of tuberculous adenitis. A tuberculous family history or tuberculous surroundings add strength to this view.

The conditions from which this must be distinguished are:

1. Simple adenitis, if such a term may be employed, but more properly an adenitis in which the dose of poison has been relatively small, and the gland has been able to dispose of it successfully; this form tends to undergo resolution.

2. A pyogenic adenitis. In this affection, which may be of the same type as the foregoing, the poison is present in larger dose; the tendency of the inflammation is toward early suppuration.

3. Syphilitic glandular enlargement will be recognized by the general and symmetrical distribution of the affected glands, especially the post-cervical and the inguinal, by the painless character of the affection, by the presence of other signs, and by the history.

4. Carcinomatous glands, secondary to epithelial cancers of the lips, tongue, etc., must be suspected if such a lesion exists or has been previously removed; hence the importance of inquiry in every case at middle age or later.

5. Glanders and other specific infections not already mentioned will be readily recognized by the presence of the primary focus of disease.

6. Bubonic plague need only be mentioned to put the surgeon on guard if the disease happens to exist in the particular locality, or if the individual has come from an infected district.

7. Lymphosarcoma may be indistinguishable from tuberculous disease of the gland in the early stages. In the later course of the case the malignant character will usually become manifest. It is sometimes proper to remove a gland for microscopic diagnosis.

8. Hodgkin's disease in the beginning presents no distinctive symptoms. It is rare before puberty: three-fourths of the cases occur in men; and the deep chain of cervical glands is apt to be the first affected. Later, the glandular enlargement becomes general, and other signs of the constitutional nature of the condition appear. The glands may be hard or soft to the touch. They very rarely suppurate.

Pathology.—See the article on *Lymph Nodes, Diseases of.*

Treatment.—The treatment of tuberculous lymph nodes may be described under the following heads: (1) The prevention of further infection; (2) rest of the part affected; (3) local applications; (4) constitutional treatment; and (5) surgical treatment.

The Prevention of Further Infection.—Before discussing the treatment of tuberculous glands something should be said on the subject of prophylaxis. In speaking of the etiology, it was stated that the disease was caused by the absorption of tubercle bacilli from some part of the surface of the body. As the majority of examples of the affection occur in the cervical glands, it will be proper to speak particularly of these. Begin by making a careful examination of every region that might furnish the infection—lesions of the scalp or face, carious teeth, ulcers of the lips, tongue, or cheeks, and particularly disease of the tonsils, nasopharyngeal catarrh, and adenoids. Nothing could be more irrational than to dose the patient with cod-liver oil, iron, etc., and to paint the skin with iodine while he is daily absorbing more germs. Even the effect of sea air and sunshine will prove futile under such circumstances. Therefore first treat the local infection atrium, in order to stop further absorption. To this end, have all carious teeth properly filled or extracted, remove adenoids, treat a nasopharyngeal catarrh, and, above all, restore the tonsils to a healthy condition, or excise them if need be, and then take up the treatment of the enlarged glands.

Rest of the Part Affected.—The first principle in the treatment of inflammatory affections is to secure rest of all the structures involved. The more acute the inflammation the more imperative this rule becomes. This course is just as necessary in treating inflammation of lymph nodes as it is in treating inflammation of other structures. For the purpose of keeping the structures of the neck at rest, in cases of cervical adenitis, a kind of "stock" should be worn. This is made of pasteboard and should be cut to fit the particular individual. The two ends meet at the back of the neck. The lower edge should rest on the clavicles, the upper margin is high at the sides, and cut out for the chin just sufficiently to permit the head to maintain a normal position. It need not be high at the back. Having carefully fitted the pasteboard to the neck, and being assured that it is of proper dimensions, the surgeon should have it lightly padded and covered with either white or black silk as preferred, and provided at the back with tapes for tying it in position. It should be worn during the night as well as during the day. If properly made it prevents rotation of the head as well as flexion and extension. In addition to affording rest to the inflamed part it serves to maintain an even temperature of the surface, which is doubtless a factor of definite value. Appropriate means for placing the important structures at rest in adenitis occurring in other parts of the body will readily suggest themselves.

Local Applications.—This is perhaps the least important part of this subject. It is probable that many of the local applications in common use are quite inert, while the most efficient have but a feeble influence. Of all the remedies employed the compounds of iodine seem to have best stood the test of time. A very efficient form of exhibiting this remedy is the ointment of the iodide of lead or of iodide of cadmium, or the compound iodine ointment, all of which are official in the Pharmacopœia. The ointment may be well rubbed into the affected region twice daily, covered with lint and waxed paper, and, if the neck is involved, the stock applied. The tincture of iodine is less efficient than the ointment, but may be liberally applied in some of the mildest cases, especially if spread well around the whole area involved.

Ichthyol in ointment (ten to fifty per cent.) or solution (five to fifteen per cent.) is highly recommended by some. The writer does not favor the practice of injecting antiseptic or irritating substances into the centre of an inflamed gland. It does not seem to be based upon a rational foundation, and besides he has not seen sufficient benefit follow the treatment to warrant its employment.

Up to a certain point the tendency of every inflamed gland is to undergo resolution and return to a condition nearly if not quite approaching the normal. If, therefore, the further absorption of poison be prevented and the parts put at rest, the symptoms will subside without any other measures.

Constitutional Treatment.—Other conditions being equal, the rapidity of improvement in the cases that undergo resolution will be in direct proportion to the health and vigor of the individual. This is to be explained by the well-known fact that the phagocytes of an individual in robust health are infinitely more efficient in destroying infections than when he is in an enfeebled state. Therefore, as an adjunct to the other measures mentioned, the patient should be instructed to lead a healthful out-of-

door life. The tubercle bacillus is killed by the direct rays of the sun, and it cannot be doubted that the effect of sunlight in increasing the resistance of persons to tuberculous infection is very great. Hence a residence at the seashore, or in the country where the individual may be in the open air all day, is to be advised. The time devoted to rest and sleep should exceed that proper for a healthy individual. Unless some special indication exists, a generous diet is to be advised. If, however, in addition to this, a liberal quantity of milk, not less than a quart a day for an adult, and an abundance of cream and butter be taken, the best results will be obtained. In other words, "forced feeding" is to be practised; at the same time the limits of the patient's digestive power must be carefully respected.

The indications for internal medication are simple. For anæmia, iron or manganese is the sheet anchor. The hypophosphites deservedly enjoy a good reputation. Arsenic given to the limits of toleration is highly indorsed by some writers, and really appears to be of invaluable service in many cases. Cod-liver oil is still very largely employed when the nutrition is poor, and perhaps nothing can be said against this practice if the stomach tolerates it well, although many prefer to administer fat in the form of cream and butter. It has not been demonstrated that cod-liver oil exerts any specific influence upon tuberculous subjects.

If the digestion is poor, pepsin or other artificial aid should be given.

Surgical Treatment.—It is frequently a matter of some moment to decide when surgical measures are necessary in these cases. Whenever a gland or group of glands is enlarging rapidly, or when the local signs of inflammation indicate that pus is either present or forming, operation should not be longer delayed. In the absence of these acute symptoms one may safely wait for as long a time as two or three months, during which the other methods of treatment may be given a thorough trial. If at the end of this time there is no improvement, the removal of the affected gland should be advised. During the time mentioned, any increase in the local symptoms would be an indication for operation without further delay. On the other hand, the simpler forms of infection which have a tendency to undergo resolution would have disappeared. Manifestations that remain after this length of time are apt to be due to tubercle, sarcoma, or Hodgkin's disease.

It is impossible to distinguish in the early stages between these three conditions, but it is equally proper to remove the affected glands in either case, for then a definite diagnosis can be made by a microscopical examination.

In operating for the removal of enlarged glands of the neck, the incision should be made sufficiently free to give proper access to the tumor, and at the same time it should be so placed as to produce the least deformity. The usual principles governing surgical operations apply to the solid forms of these tumors. As the majority of these operations will be for tuberculous glands, it should be emphasized that satisfactory results will only follow thorough removal. Before the glands have broken down this will be a task of comparative ease. After abscesses have formed, however, the dissection is much more tedious, and the chance of obtaining a radical cure is much diminished. In neglected cases and those in which early breaking down has occurred, it has been a common practice to incise the fluctuating swelling and treat it as an ordinary abscess. It will be found in many of these cases that the pus comes from a suppurating gland beneath the deep fascia, and that the discharge has worked its way through the latter and has appeared beneath the skin. With this knowledge, it is our duty in these cases, after incising the abscess, to explore carefully in all directions for any evidence of a track leading to a deeper focus of suppuration. If such be found, it must be followed up and treated in the usual way. The deep glands of the neck lie in close apposition to the great blood-vessels, and when the seat of disease they are particularly prone to involve the internal jugular vein. In all operations, the important anatomical structures which lie in apposition with the glands must be kept in mind and avoided if possible. If the internal jugular vein is distinctly involved, a ligature may be applied on either side of the part affected and the section removed. In order to get better access, if the disease is extensive, the sterno-mastoid muscle may be divided and sutured again after the mass has been removed. In the absence of pus these wounds may be closed without drainage, but when suppuration is present suitable drainage must be provided.

Alfred C. Wood.

LYSIDIN—ethylene-ethenyl-diamine, methyl glyoxalidin ($NCH_2.NHCH_2.CCH_3$)—a reddish-white, very hygroscopic crystalline mass of mouse-like odor and alkaline reaction, is prepared by acting on ethylene-diamine hydrochloride with sodium acetate, and separation by caustic alkali. It is freely soluble in water and alcohol, is insoluble in ether, decomposes silver nitrate, and with ferric, zinc, and mercuric chlorides and iodides forms precipitates which are soluble in excess of lysidin. One gram of lysidin requires for neutralization 5 c.c. normal hydrochloric-acid solution. The drug, on account of its hygroscopic nature, is marketed only in fifty-per-cent. aqueous solution, a pale-yellow liquid with soapy feel.

Lysidin is a near relative of piperazin, and, like the latter, has a noteworthy value in gouty conditions. Goodbody considers it more powerful than piperazin as a solvent for uric acid, and Gompertz, Grawitz, and others give favorable reports of its action. The dose is 2 to 10 c.c. (ʒ ss.–iss.) of the solution daily, given with large quantities of water.

Lysidin bitartrate is a soluble white crystalline salt of lysidin of about one-third the strength of the latter.

W. A. Bastedo.

LYSOFORM is an odorless, clear, yellowish, soapy liquid containing formaldehyde, and miscible in all proportions with water (slightly cloudy) and alcohol. Symanski, to make a comparative study of lysoform with lysol, mixed urine with bouillon, incubated it for three days, and added 0.1 to 1.0 c.c. of lysol and lysoform, respectively, to 100 c.c. Platings were made after twenty-four, thirty-six, and seventy-two hours. In 0.5–1 c.c. mixtures the lysol plates were sterile, while cultures were obtained from all of the lysoform plates; the strong lysoform solutions were about equal in antiseptic power to the weak lysol solutions. Spore-forming anthrax bacilli were killed by two- to three-per-cent. lysol, and by three- to five-per-cent. lysoform. Lysoform had but little antiseptic power on albuminous fluids, but possessed the greatest deodorizing power. Inoculated into mice and guinea-pigs it is very little poisonous. For cystitis, Simons recommends injections of 10–30 c.c. (ʒ iiss.–℥ i.) of two-per-cent. solution, and for chronic gonorrhœa one-per-cent. Strassmann uses it as a vaginal douche, and in two- to four-per-cent. aqueous or alcoholic solution as a disinfectant for the hands. *W. A. Bastedo.*

LYSOL.—This is a proprietary preparation of cresol introduced to supersede creolin, the best-known solution of this valuable disinfectant. The advantages claimed for lysol over the other cresol compounds are that it forms a clear solution when mixed with water, contains a greater amount of cresol, and is perfectly free from injurious qualities. It is said to be prepared by dissolving the cresols, which distil between 190° C. and 200° C. in fatty matter and subsequently saponifying by the addition of alcohol. It is a brown, oily-looking, clear liquid, with a feeble, aromatic, creosote-like odor. It is said to contain fifty per cent. of cresol. Its solution forms a soapy, frothing fluid, which becomes turbid only when mixed with hard water, the extent depending upon the quantity of lime salt present; this turbidity increases upon standing for some time. Lysol mixes freely with alcohol, glycerin, chloroform, and benzene.

For surgical purposes it is used in different degrees of

strength. For disinfecting the hands and cleansing the body of the patient, a five-per-cent. solution is used by rubbing into the parts thoroughly, and then washing it off in a solution of one or two per cent. For disinfecting instruments and for irrigation during an operation a one- or two-per-cent. solution is prepared, and for gynecological and obstetrical purposes a solution of one-half per cent. is sufficient.

On mucous surfaces, when used in stronger solution than two per cent., it causes a burning and painful sensation which lasts for some time, but otherwise is perfectly unirritating.

Lysol was recommended for internal administration as an antiseptic remedy, but has not proved of much service. In Europe it is more frequently used as an antiseptic injection in disturbances of the lower bowel, a solution of the strength of one per cent. being employed.

Beaumont Small.

LYSOL, POISONING BY.—Lysol is a coal-tar product containing a considerable amount of cresols (methyl-phenols) which by conversion into sodium salts have been rendered soluble in water. It is used a good deal as an antiseptic wash, and cases frequently occur in which it is the cause of poisoning by being mistaken for other substances in use in the sick-room. Out of 18 cases recently collected from current literature, 13 were from internal and 5 from external use of the remedy. Nine of the cases resulted fatally: 5 children and 1 adult after internal use and 2 children and 1 adult after external application of the pure lysol when the 1-per-cent. solution had been ordered. The largest dose from which recovery is recorded is 60 gm. (about gr. 925) in the case of a woman and 25 gm. (gr. 385) in a four-year-old child. The smallest doses that have proved fatal were a teaspoonful (about 4.3 gm. or gr. 70) in children between five and eight years old.

The recent cases show that the prompt washing out of the stomach freely with water has been attended with satisfactory results, while the neglect of this was usually fatal. The solution should never be used externally in strength greater than one per cent., nor more than 0.5 per cent. internally.

The following recently reported case will serve to show the general nature of severe lysol poisoning. A child of nearly two years old drank a teaspoonful of lysol at 8 P.M. Milk was given at once, but unconsciousness soon supervened without cramps or vomiting. At 8:15, when the physician saw the child, the pulse was 160, small and irregular, cyanosis marked; corneal and pupillary reflexes were absent. The mouth contained considerable mucus, and the mucous surface was corroded, as was also the skin, at the corners of the mouth and on the chin. At 8:30 P.M. the stomach was washed out with water until the effluent had no odor of lysol. Camphor and ether injections were used. The child improved, consciousness returned, but there were several attacks of vomiting during the night. Next morning, the temperature was 102.2° F. and pulse 120, moderately strong, but dyspnœa developed, the œdema of the lung increased, unconsciousness again supervened, and the patient died at 3 P.M., nineteen hours after taking the poison.

The local effects of lysol will resemble those of phenol in some respects, but the corrosive effects will be less marked. On the other hand, the general effects of lysol are well-marked features of its action, and death may occur without extensive local injury. The above case was treated by washing out the stomach, but rather late and after much lysol had been absorbed.

Henry Leffmann.

LYSULFOL is a thick black viscous liquid containing lysol and sulphur. It is miscible with water and is used by Rumpf in skin diseases. *W. A. Bastedo.*

MACE.—*Macis. Banda Mace.* The arrilode of the seed of *Myristica fragrans* Houttuyn (fam. *Myristicaceæ*). The origin and preparation of mace are fully explained under *Nutmeg.* It occurs in narrow bands, 2.5 cm. (1 inch) or more long, somewhat branched and lobed above, united into broader bands below; orange-brown, exuding fat when scratched or pressed; odor fragrant; taste warm and aromatic. In the ground condition, mace is almost always grossly adulterated, especially with the wild or Bombay mace, from *Myristica Malabarica.* This is longer and more slender, of much darker color, softer, weaker, and more flexible and contains very little volatile oil, but a good deal of resin, by means of which its powder is readily distinguished. Curcuma, ginger, and similar substances are also considerably used in the adulteration of mace, and are readily distinguished by a similar resinous nature, as well as by their starches.

A good mace contains eight per cent. or more of volatile oil, a large amount of fat, very little resin, a little sugar, and other ordinary vegetable constituents. It is free from starch. The ash should not exceed two per cent. and in a clean article is considerably less.

The volatile oil of mace is slightly heavier than that of nutmeg and is soluble in three parts of alcohol. It is of complex composition, being identical in this respect with oil of nutmeg, except that its content of terpene is somewhat smaller. Owing to this practical identity of the two oils and the greater cheapness of oil of nutmeg, it happens that commercial "oil of mace" is almost without exception oil of nutmeg.

The action, uses, and dosage of mace are those of nutmeg. *Henry H. Rusby.*

MADDER.—*Rubia.* The root of *Rubia tinctoria* L. (fam. *Rubiaceæ*). Rubia is a perennial herb, native of the Orient and extensively cultivated there. The dried root is cylindrical, elongated, 0.3 to 1 cm. ($\frac{1}{8}$ to $\frac{2}{5}$ inch) in diameter, externally dark reddish-brown, internally somewhat lighter to pink. It is of soft texture, slight odor, and a sweetish, slightly astringent and bitter taste, tinging the saliva red. It is of complex composition, the source of its coloring matter being one or more glucosides which are decomposed by various processes employed in forming it. The drug has entirely lost its place as a medicinal agent and is now exclusively used for dyeing. Even this use has largely declined under the influence of the aniline dyes. *Henry H. Rusby.*

MADEIRA.—The island of Madeira, the largest of the group of islands bearing that name, lies off the Morocco coast of Africa at a distance of about three hundred and sixty miles, and about three hundred miles to the north of the Canaries. It is one of the best types of the warm moist climates, and some fifty or more years ago was considered by the English the ideal climate for pulmonary tuberculosis and other lung diseases: much in the same way as Florida in this country was formerly regarded as the Mecca for consumptives. The extent of the island is about thirty miles from east to west, and thirteen miles wide. Extending from one end to the other is a range of mountains averaging 4,000 feet in height, with a maximum of 6,100 feet (Pico Ruivo, in the centre of the island). The side ridges of this central chain extend to the coast in every direction, usually terminating in lofty headlands. The north coast is more precipitous and wilder than the south. The soil is fertile, and on the mountain slopes are gardens with luxuriant semitropical vegetation and vineyards.

Madeira belongs to Portugal and "the inhabitants are of Portuguese descent, with some admixture of Moorish and negro" (Solly). The population of the two inhabited islands, Madeira and Porto Santo, is about 134,000. Funchal, the capital and largest town of Madeira (population 22,000), lies upon the south coast, and is built around the curving shore of a bay, extending up the encircling hillside to a height of 350 feet or more above sea level. It is sheltered from the northerly winds, which are prevalent, by the mountain chain, and is the usual place of residence selected by invalids resorting to the island during the season which extends from September to May, though one can spend the summer comfortably

ANNUAL AVERAGES.

	Latitude.	Temperature. (Degrees Fahrenheit.)			Relative Humidity.	Rainfall.	Cloudy Days.
		Mean for January.	Mean for July.	Mean Annual.			
Madeira	32°30′ N.	60.4°	71.1°	66.2°	70.75%	29.0	110.0
Jupiter, Fla.	26°57 N.	63.4	80.5	73.4	82.	62.1	79.8
Key West	24°34′ N.	70.3	84.	77.5	73.9	40.8	59.1
Jacksonville	30°20′ N.	55.8	82.5	69.2	72.	54.6	85.1
Santa Barbara	34°28′ N.	51.2	66.8	60.7	73.	17.6	71.
San Diego	32°43′ N.	53.6	67.1	60.4	72.9	9.49	87.2
Bermuda	32°15′ N.	62.5	79.8	70.8	80.	62.54	83.
Nassau	25°5′ N.	69.	87.	78.7	79.	56.	
Mentone	43°46′ N.	49.3	Summer. 73.	60.	72.	Oct. to May. 25.61	80.
Cairo	30°3′ N.	53.6	77.9	70.2	58.4	1.22	40.
Aiken	33°32′ N.	44.15	78.8	61.61	59.65	48.	

on the island by going up into the mountains. The scenery is very attractive and varied. The roads are very steep, so that wheeled vehicles are rarely used, but in their place palanquins, sledges, and portable hammocks. The sanitation and water are good. The accommodations are excellent, there being several English hotels and furnished villas called "quintas" for rent, situated at various elevations. There are also English and Scotch churches, and an English club and library. There are good fishing and sea-bathing all the year round, the temperature of the water in winter being from 60° to 70° F.

Madeira is reached by steam from Liverpool, London, Southampton, and Plymouth, and from various others ports on the Continent, and is also frequently a point of call by steamers from New York taking the southern route.

As has been said, the climate of Madeira is a mild, moist, marine one, and is consequently a very equable one, not only in the daily but also in the yearly range. The average mean daily range for the year is 9.2° F. and the mean nycthemeral range during the six months, November to April, is only 10° F. The mean monthly range of temperature for each of the five months—November to March—is as follows:

November, 16°; December, 16.9°; January, 16.9°; February, 18.7°; March, 18.9°. The mean annual temperature is 66.2°, and for the winter 61.6°. The extreme range of temperature is from 90.8° to 46.22° F., for eight years of observation.

At Funchal frost and snow are wholly unknown, but snow falls on the mountains once or twice during the winter, very seldom, however, below the altitude of two thousand feet. The mean annual relative humidity is given as from 70 to 75 per cent., and for the five months from November to March, 71 per cent., according to Kisch. During spring and autumn the relative humidity is least. The mean annual rainfall is 29 inches, of which 66 per cent. falls in the four months, November to February. In the winter six months there are on an average fifty rainy days. Lombard gives the number of cloudy days per annum as 110, and of fair and clear days as 189. The prevailing winds are from the north, northeast, and northwest. Generally there are no high winds at Funchal, but occasionally it is visited by the "leste," a hot dry wind blowing from the Morocco coast, chiefly in the spring and autumn.

In the above table the climate of Madeira is compared with various other warm marine climates and with the dry climates of Cairo and Aiken.

The climate of Madeira is not suited, in the writer's opinion, for pulmonary tuberculosis generally, although occasionally individual cases may do well, as in almost any climate. No warm, moist marine climate can be considered favorable for the arrest or cure of this disease, and experience, especially that at Madeira, confirms this statement. For cases of chronic laryngitis with scanty expectoration, chronic bronchitis and emphysema, however, such a climate is favorable, as well as for that large class of cases characterized by debility. "The feeble, flickering lamp burns longer there than in a more stimulating and tonic air, and now and then it seems to gather renewed power, and burns up again with some of its old lustre." For delicate scrofulous children such a mild marine climate is of value. Kisch regards rheumatism and gout, and also a tendency to diarrhœa and to albuminuria, as contraindicating the Madeira climate.

The American in search of health would rarely seek Madeira, owing to the long and expensive journey which he would be obliged to take. Moreover, he has nearer at hand in Florida, Southern California, and the West Indies, similar or more favorable climates.

Edward O. Otis.

MADRUGA SPRINGS.—These springs are situated in the town of the same name at a distance of about forty-five miles from Havana, Cuba, with which the town is connected by railroad. The number of springs is quite large, but up to the present only three of them have been employed for medicinal purposes, their names being, Paila, Templado, and Tigre.

These springs have been well known for many years and have enjoyed a well-merited fame, but for a long period they were neglected. Finally, the people of the neighborhood formed an association which furnished the necessary funds for erecting the buildings which now exist on the site of the springs. These buildings are substantial in character, made of stone, and roofed with tiles in the picturesque manner of the country.

The building at the Paila is thirty-six feet long by eighteen feet in width, and in the middle there is a partition wall which serves to divide the building into two almost equal parts. One side is devoted to the use of women and children, while the other division is for men bathers. The water that fills both of these tanks issues from a spring located in a well six feet wide by nine feet deep.

The water of this spring is clear, transparent, and has a strong odor of sulphureted hydrogen. This odor is lost on boiling the water or when it is allowed to cool. The temperature of the water is about 23° C.; in reaction it is somewhat alkaline.

The analysis of the water of this spring, according to Dr. Aenlle, yields the following results:

	Gms. per Litre.
Sulphurous acid	.228
Carbonic acid	.112
Carbonate of magnesium	.078
Carbonate of calcium	.486
Sulphate of calcium	.384
Chloride of sodium	.098
Carbonate of iron	.008
Chloride of magnesium	.018
Oxide of aluminum	.013
Organic matter	.049
Total	1.474

A more recent analysis made by Dr. Pons gives a somewhat different result, which is as follows:

	Gms. per Litre.
Sulphate of calcium	1.300
Chloride of sodium	.020
Carbonate of magnesium	.150
Alumina	.009
Carbonate of calcium	.008
Sulphate of iron, Carbonate of iron peroxide, Silica, Nitrogen or organic matter	.198
Total	1.685

The Tigre Spring has not the volume of the others, but the bathing facilities are also good, the building at this spring containing separate apartments for men and women. The water is colder and has a larger amount of sulphate of iron.

The curative powers of the waters of these springs have long been known by the people of Cuba and they have been acknowledged also by the medical profession. In fact, they enjoy almost as much popularity as do those of San Diego. Dr. Pardinas, resident physician and medical director of the bathing establishment at Madruga Springs, has devoted much attention to the treatment of disease by these waters, and has furthermore published his experiences; I can therefore do no better than quote him. He finds the waters of most benefit in various forms of anæmia, and he has published a series of cases in which the blood count has rapidly risen under their use from 3,200,000 to 4,000,000, or even 5,000,000, in less than two weeks.

Although it is well known that cold sulphur water baths are not generally indicated in the treatment of rheumatic conditions, it is nevertheless true that very few sufferers from affections of this nature have failed to derive some benefit from a course of treatment at these springs. Almost all the conditions coming under the heads of arthritism, scrofula, and herpetism seem to improve under their use. The records show numerous cases of bronchitis, dyspepsia, neuralgia, cholelithiasis, cystitis, etc., in which a cure has resulted from a course of treatment at this establishment. The next most common condition among the patients coming to these springs is the group of diseases termed "herpetism." The effect of the treatment on these troubles is truly remarkable, a cure sometimes following a short series of baths. The best results are obtained in the dry form of diseases of the skin. The baths are of course contraindicated during the acute or active period of these affections.

N. J. Ponce de Léon.

MADURA FOOT. See *Actinomycosis.*

MAGNESIUM.—I. General Medicinal Properties of Compounds of Magnesium.—Medicinally, magnesium is notable among metals for its inertness, its compounds exhibiting absolutely no specific effect individual to their basic radical. As a class, magnesic salts tend to be of low diffusion power and purgative, and, as compared with salts of potassium or of sodium with the same acid radicals, are less obnoxious to the taste and are generally milder in action.

II. The Compounds of Magnesium used in Medicine.—The compounds of magnesium entering into preparations of the United States Pharmacopœia are the *oxide* ("magnesia"), *hydroxide, carbonate, citrate,* and *sulphate.*

Magnesium Oxide, MgO.—Magnesium oxide, the *magnesia* or *calcined magnesia* of common parlance, is easily obtained by exposing to a low red heat the so-called magnesium carbonate of pharmacy. According to special circumstances in the making, magnesia may be comparatively light or comparatively heavy. Two grades of magnesia thus occur in the markets, both of which are recognized by the United States Pharmacopœia. The *light* variety is officially entitled, simply, *Magnesia,* Magnesia, while the heavy grade is distinctively styled *Magnesia Ponderosa,* Heavy Magnesia. The market brands of magnesia known, respectively, as *Henry's, Husband's,* and *Ellis's,* are examples of heavy magnesia.

Both varieties of the substance are in the form of an exceedingly fine white powder, very light in the case of the simple "magnesia," but dense in the case of the "heavy" article. In both cases the powder is odorless, but with an earthy, though not saline taste; is almost insoluble in water, and quite so in alcohol. In the case of the light variety, one part of magnesia mixed with fifteen parts of water and allowed to stand for half an hour will form a gelatinous magma of magnesium hydroxide. Heavy magnesia, on the contrary, does not readily react in this way. Magnesia slowly absorbs carbon dioxide from the atmosphere, and hence is directed by the Pharmacopœia to be kept in well-closed vessels.

Magnesia is strongly alkaline in respect of power of saturating acids, but, from its feeble solubility, shows scarcely a trace of the physiological properties exhibited by the soluble alkalies potassa and soda. Locally, magnesia has only the negative properties of a light, smooth, insoluble powder, but taken internally it neutralizes acids in the primæ viæ, and in the condition of a soluble magnesian salt thus resulting proves mildly laxative. As an internal medicine, in short, magnesia combines the properties of an antacid and a laxative, and is used exclusively for obtaining the effects of such virtues, either singly or together. Thus it may be prescribed as a simple laxative in constipation, a simple antacid in "sour stomach," or as a medicine of both virtues when, in the case of irritation of the intestines from the products of sour fermentation of the food, both an alkaline and a laxative effect are needed. When given as a simple laxative, it may be necessary to follow the dose of magnesia with a draught of lemonade to secure the necessary acid for the solution of the magnesia. As an antacid, magnesia is given in doses of from 0.65 to 2 gm. (gr. x.-xxx.) and as a laxative from 2 to 4 gm. (gr. xxx.-lx.). It is administered rubbed to a smooth cream with water or milk, and, in general, "heavy" magnesias are preferable to the "light" variety, by reason of their being more readily miscible with fluids. A mixture of magnesia with water, if not weaker than one part to fifteen, slowly gelatinizes on standing as stated above by formation of magnesium hydroxide, and if kept for a day or two may cake into lumps. And such concretions have been found, post mortem, in the human stomach, after habitual full dosing with magnesia.

Magnesium Hydroxide, $Mg(OH)_2$.—Magnesium hydroxide, or *hydrate of magnesia,* is not official under its own form, but is an integral part of the composite so-called *carbonate* of the United States Pharmacopœia, and is what forms on allowing an aqueous mixture of magnesium oxide to stand, as above described. Magnesium hydroxide also occurs as a bulky gelatinous precipitate on decomposing, by caustic soda, magnesium sulphate (Epsom salt) in solution. Such a precipitate, washed and diffused in enough water to make the mixture of creamy consistence, constitutes a preparation that is exceedingly convenient as a means of administering magnesia, and which, if the hydroxide have been thoroughly washed and if the water employed for the dilution be perfectly pure, has a mild taste only, resembling that of milk, and will keep without change. A tablespoonful of such preparation is a full antacid dose for an adult, and two tablespoonfuls a laxative. Excellent articles of this preparation are in the market, under the title *milk of magnesia.*

Magnesium Carbonate, $MgCO_3$.—Normal magnesium carbonate is not used in medicine, but under the title *Magnesii Carbonas,* Magnesium Carbonate, the United States Pharmacopœia makes official the well-known *magnesia alba* of the shops, a composite salt, which may be regarded as a compound, in variable proportions, of normal magnesium carbonate and magnesium hydroxide. The United States Pharmacopœia recognizes the composition represented by the formula $(MgCO_3)_4$, $Mg(OH)_2$,

$5H_2O$. This compound forms as a white precipitate on mixing solutions of magnesium sulphate (Epsom salt) and sodium carbonate. Collected, washed, and dried, it then appears as light, white, friable masses, or a light, white powder, odorless and tasteless, insoluble in alcohol, and almost insoluble in water, to which, however, it imparts a feebly alkaline reaction. When strongly heated, it loses water and carbonic acid gas, and is converted into magnesia. It is soluble in dilute acids with copious effervescence. Magnesia alba is made in two grades of density, technically known, respectively, as the *light* and *heavy*. The difference is said to be determined by the strength of the solutions used for the precipitation, concentrated solutions producing a heavy, and weak a light, product. The United States Pharmacopœia does not contradistinguish the grades of density nor direct the process of manufacture, and, as a matter of fact, much of the commercial carbonate is prepared from dolomite.

Magnesia alba is practically identical in medicinal properties with magnesia, and may be used for the same purposes as that compound. The former is, however, the inferior remedy, first, because in its uniting with acids in the primæ viæ it necessarily evolves gas—an unpleasant circumstance; and secondly, because it needs to be given in double the doses of magnesia. Magnesia alba is administered, like magnesia, rubbed to a cream with water or milk, an operation which is greatly facilitated by first rubbing the powder with a little undiluted syrup.

Acid Magnesium Citrate ($MgHC_6H_5O_7$).—This salt is official in the United States Pharmacopœia only in composite pharmaceutical preparations, as follows: *Liquor Magnesii Citratis*, Solution of Magnesium Citrate. The salt is formed in solution by adding the pharmacopœial carbonate to a solution of citric acid; the solution is flavored with syrup of citric acid, and the mixture being put into a twelve-ounce bottle, a small charge of acid potassium carbonate ("bicarbonate") is finally added, and the bottle instantly, thereupon, securely corked, the cork being fixed in place by twine. Reaction now takes place between an excess of citric acid present in the mixture and the potassium carbonate, whereby potassium citrate forms and carbon dioxide gas is evolved. But the bottle being stoppered, the gas is retained and remains in solution under pressure. Thus there is obtained an acidulous, sweetened, and actively effervescing aqueous solution of magnesium citrate, with a little potassium citrate. For the making, the quantity of 15 gm. (gr. ccxxxi.) of magnesian carbonate is ordered for each twelve-ounce bottleful. The solution, in taste, strongly resembles ordinary "lemon soda." *Magnesii Citras Effervescens*, Effervescent Magnesium Citrate. To make this preparation, magnesium citrate is first formed by mixing magnesium carbonate and citric acid together with enough water to make a paste; the resulting mass is then dried, powdered, and mixed with some acid sodium carbonate, sugar, and additional citric acid, in powder. The whole is then dampened with alcohol, granulated, and again dried. The product is a white, coarsely granular salt, deliquescent on exposure to air, odorless, having a mildly acidulous, refreshing taste, and an acid reaction. It dissolves, with copious effervescence, in two parts of cold water, and is still more soluble in boiling water. It is insoluble in alcohol. This salt furnishes, substantially, in solid form, the ingredients of the foregoing solution of the citrate, and its solution, extemporaneously made, practically represents the official solution of the citrate. The preparation should be kept in well-closed bottles. The proportion of magnesic carbonate ordered for making the granulated compound is ten parts for one hundred of product.

Magnesium citrate is a simple saline purgative, mild in character, not disagreeable to taste, and generally very well borne by the stomach. The agreeable flavoring and effervescent property of the pharmaceutical representatives of the salt make the medicine an especially appropriate one for children, or for use in fevered states requiring the action of a purge. The official solution, it will be observed, comes only in twelve-ounce bottles. One bottleful is a purgative dose for an adult, but it is generally given only in wineglassful doses, sipped during the day, so that half a bottleful or more is consumed in the twenty-four hours. The fluid should be ice-cold, and the bottle should instantly be recorked after the drawing off of each dose, and kept, set upside down, in a cool place. But after once opening a bottle, the solution is not good for longer than a day. The granulated salt is to be given in doses of from one to three teaspoonfuls, dissolved, at the time of taking, in iced water, and the solution drunk during effervescence.

Magnesium Sulphate ($MgSO_4.7H_2O$).—Magnesium Sulphate—the well-known *Epsom Salt*—is official in the United States Pharmacopœia as *Magnesii Sulphas*, Magnesium Sulphate. It is a widely distributed salt, being an ingredient of sea-water, and of the water of some saline springs, and occurring also native. It is prepared for commerce in a number of ways. Magnesium Sulphate occurs in small, colorless, right-rhombic prisms, or circular needles, slowly efflorescent in dry air, odorless, having a cooling, saline, bitter and disagreeable taste, and a neutral reaction. It dissolves in one and a half parts of cold water and very freely in boiling water. It is insoluble in alcohol.

Magnesium sulphate is a typical saline purge, and, although of very disagreeable taste, is usually well borne by the stomach. In excessive dose, however, it induces nausea and vomiting in addition to profuse purging. In small, repeated doses the salt may prove slightly diuretic, and often in such doses it makes an excellent corrective in ordinary gastric derangement. A full purgative dose for an adult is 30 gm. (℥ i.), but if taken, as preferably it should be, immediately upon rising in the morning, on an empty stomach, one-fourth of such amount may be sufficient for a purge. As a corrective, 0.30 gm. (gr. v.) may be given at a dose, repeated a number of times daily. The salt is best given dissolved in ice-cold lemon soda. Magnesium sulphate is by far the most commonly used saline purgative, and hence the non-distinctive phrase, a *dose of salts*, is commonly held to mean a dose of this particular salt. *Bitter purging salt*, and, simply *bitter salt*, are also common names for the sulphate. Epsom salt is an ingredient of the pharmacopœial *compound infusion of senna*.

Edward Curtis.

MAGNESIUM CREOSOTATE, Kreosolid, creosote-magnesia, is a mixture of creosote and calcined magnesia which, being free from odor or taste of creosote, is a convenient means for administering this remedy. Dose gm. 0.5 (gr. viij.) three or four times a day.

W. A. Bastedo.

MAGNESIUM ICHTHYOLATE is prepared by mixing 100 parts of recently calcined magnesia with 775 parts of ichthyol and evaporating to dryness. It is used with talc as an antiseptic dusting powder. *W. A. Bastedo.*

MAGNESIUM LORETINATES, basic and neutral, are substitutes for iodoform (see *Loretin*). The basic salt, $MgI.O.C_9H_4N.SO_3.5H_2O$, occurs as sparingly soluble yellow crystals, and the neutral salt, $Mg\,(I.OH.C_9H_4.N.SO_3)_2.7H_2O$, in readily soluble salmon-colored prisms.

W. A. Bastedo.

MAGNESIUM PHENOL-SULPHONATE, or sulphophenate, occurs in the form of white, almost odorless needles of bitterish taste and alkaline reaction. It is soluble in 2 parts of water and 5 of alcohol, and in dose of 1 to 2 gm. (gr. xv.–xxx.) is recommended as a useful saline aperient similar to magnesium sulphate.

W. A. Bastedo.

MAGNETIC MINERAL SPRING.—Vigo County, Indiana.

POST-OFFICE.—Terre Haute.

This water is procured from an artesian well, 2,000 feet deep, at the foot of Walnut Street, in the city of Terre Haute. The point is accessible by any street-car

line in the city. A very elaborate natatorium and bath-house have been established. All kinds of hot, cold, vapor, swimming, or mud baths may be had under the direction of Dr. H. S. Tanner, of fasting fame. The water has been analyzed by Prof. W. A. Noyes, of the Rose Polytechnic Institute, with the following result:

One United States Gallon Contains:

Solids.	Grains.
Silica	0.71
Alumina	.17
Strontium chloride	Trace
Calcium chloride	16.27
Calcium sulphide	2.07
Calcium sulphate	.27
Calcium bicarbonate	21.94
Calcium phosphate	Trace
Magnesium chloride	13.94
Magnesium bicarbonate	16.44
Lithium	More than a trace
Potassium chloride	3.95
Sodium borate (borax)	More than a trace
Sodium iodide	Trace
Sodium bromide	More than a trace
Sodium chloride	347.73
Hydrogen sulphide	5.87
Methane (marsh gas)	More than a trace
Total	429.36

Temperature of water, 50° F.

The waters are mildly aperient, alterative, and tonic. They will be found useful in the disordered states usually benefited by this class of waters.

James K. Crook.

MAGNETISM, ANIMAL. See *Hypnosis.*

MAGNOLIA and **MAGNOLIACEÆ.** (*The Magnolia Family.*)—This is a small family of trees and shrubs, mostly of warm temperate regions, many of them highly esteemed for their ornamental and fragrant properties. Some valuable timbers are yielded by the larger trees. The bark and herbage are generally permeated by volatile oil and amaroids, so that many of them have been rather extensively used as aromatic bitters. This is especially true of the bark of several species of *Magnolia,* containing *magnolin,* and *Liriodendron,* containing *liriodendrin.* Under the title of "*Magnolia,*" *M. virginiana* L., *M. tripetala* L., and *M. acuminata* L., all of the Southern United States, were long official. Their bark is given in doses of 2 to 4 gm. (ʒ ss.–i.).

Henry H. Rusby.

MAGNOLIA SPRING.—Sumter County, Georgia.

Post-Office.—Plains of Dura.

Access.—Viâ Southwestern Railroad to Americus, thence by private conveyance to spring.

This spring has been known for many years, and has been steadily gaining in popularity as a place of local resort. No analysis of the water has been made, but it is said to contain iron and sulphur. There is some gas given off, probably carbonic acid. The iron is in sufficient quantity to impart its taste very distinctly to the water. The flow is large, being about fifty gallons per minute. There is a good bath-house, and visitors can find accommodations in private families.

James K. Crook.

MALAKIN, salicyl-para-phenetidin, salicylidene phenetidin ($C_6H_4.OC_2H_5.N.CH.C_6H_4.OH$), is a combination of paraphenetidin, the mother substance of phenacetin with salicylic aldehyde. It occurs in small odorless and tasteless silky yellow needles which are almost insoluble in water and cold alcohol but readily soluble in hot alcohol or ether. In a caustic soda solution it dissolves with intense yellow color; and with mineral acids or acid salts it is decomposed into its components, the salicylic aldehyde giving the well-known odor of meadow-sweet. About fifty per cent. of the compound is aldehyde. The urine contains salicyluric acid (Schmiedeberg).

Jacquet introduced malakin in 1893 as a remedy for acute rheumatism. As an antipyretic and sedative it resembles the other drugs of the phenacetin class, but it is slowly absorbed, hence its action is slow and mild. It is split into its components by the gastric juice. As the dose of the drug is small, the amount of salicylic compound must be of little avail in acute rheumatism, though it may be suitable after the acute symptoms have subsided. Abernethy, of Edinburgh, finds it very useful as an antipyretic, but of only moderate value in rheumatism. Ottolenghi has proposed it as an anthelmintic. The dose is 4 to 6 gm. (ʒ i.–iss.) a day in capsules or powder.

W. A. Bastedo.

MALARIA. See *Plasmodium Malariæ.*

MALARIAL DISEASES.—Malarial diseases consist, first, of *fevers,* intermittent or remittent, benign or pernicious, and, second, of a condition of chronic ill-health known as *malarial cachexia.*

The fevers are infectious in their nature, characterized by regular intermissions or less regular remissions, and are caused by the presence in the blood of certain protozoa or hæmacytozoa, discovered by A. Laveran in 1880 and called by him the *plasmodium malariæ.* The principal and perhaps the only way in which man is infected with this plasmodium is through the bite of a certain variety of the mosquito, known as the *Anopheles.* This Anopheles mosquito must previously have sucked the blood of a malarial patient and thus have become the "intermediate host" of the malarial parasite, which, having gone through with a certain necessary portion of its life and development within the organism of the mosquito, is now ready for re-introduction into and renewed life in the human blood.

From the earliest history of medicine to the present day malarial fevers have been known to be practically confined to marshy regions in certain portions of the temperate and tropical zones. They have been believed to be caused by emanations from the soil of such regions, known as "marsh miasms." The fact that the Anopheles mosquito which has sucked the blood of a malarial patient and which, after a certain length of time, bites a non-malarial subject, can thereby infect the latter with malaria has been proved beyond all question. But this does not establish the true origin of the malarial germ or parasite. Whence did the first man or the first mosquito obtain the malarial germ? This question is not yet answered by science. It is not unreasonable to suppose that the origin of the germ will yet be found to be in the soil or the water or the plant of a malarial region, beginning its existence outside of any animal body, even, though, perhaps, always introduced into man by the bite of the mosquito. Science has not yet spoken the last word on this subject.

For a full history and description of the malarial parasite the reader is referred to the article on *Plasmodium Malariæ,* in Vol. VI. of this Handbook.

The *mosquito,* as a disease-carrier, is fully treated of under the head of *Mosquitos in their Relation to Human Pathology,* in the present volume.

It therefore remains for this article to consider only the clinical history, the pathology, and the treatment of malarial diseases.

Malarial Fevers are divided into (1) *ordinary* or *simple intermittent fevers,* which are benign, and (2) *irregular, remittent,* or *continued fevers,* which may be either benign or pernicious. The second class, whether benign or malignant, are now called "*æstivo-autumnal fevers*" (summer-autumn fevers), because in the neighborhood of Rome, where the organisms causing these fevers were first carefully studied, such fevers prevail in the summer and autumn alone. The only reason for retaining the name is because the variety of parasite giving rise to these continued or remittent fevers has, by most parasitologists, been designated as the æstivo-autumnal parasite.

While there is still a difference of opinion among authorities as to the number of species of malarial parasites that exist, there is a general consensus of opinion as to the existence of at least three well-defined species, viz.:

1st, the simple tertian; 2d, the simple quartan; and 3d, the æstivo-autumnal parasite, the latter being divided into two varieties: (*a*) the one producing true quotidian æstivo-autumnal fever and (*b*) the one producing the æstivo-autumnal tertian.

The first two species give rise to all the simple intermittent fevers and the third species to all the irregular, remittent, or continued fevers, whether benign or malignant. These different species can be distinguished from one another, by those familiar with the subject, by their size, growth, pigmentation, method of sporulation, etc.

INTERMITTENT FEVER.—This is the variety of fever characterized by a chill, fever, and sweat, occupying a part of the twenty-four hours, followed by an interval, before the next paroxysm, of some hours or days, during which there is no fever. The cause of a paroxysm of intermittent fever is the fact that a generation of malarial parasites, of sufficient number, in the blood corpuscles of the patient, arrive at maturity and sporulate. If these parasites be of the simple tertian species they will mature and sporulate every forty-eight hours or every other day. The terms tertian and quartan are misleading until we remember that the ancients counted every fever day both as a third or fourth day and as a new first day. A tertian, therefore, has one well day between two consecutive fever days, and a quartan has two well days between the fever days. Let us suppose that a man is infected with two separate generations of tertian parasites, maturing on successive days, which is a very frequent occurrence. Such a man has a double tertian intermittent, which means that he has a quotidian or daily fever, caused, however, by the tertian parasite, as is shown by the following diagram, where A and B represent the two generations.

Double tertian -

A days.........	1	2	3′	2	3′	2	3′	2
	A	B	A	B	A	B	A	B
B days.........		1	2	3′	2	3′	2	3′

The quotidians may also be formed of a triple quartan, three generations of quartan parasites, A B and C in the diagram, maturing on three successive days.

Triple quartan—

A days	1	2	3	4′	2	3	4′	2	3′
	A	B	C	A	B	C	A	B	C
B days...........		1	2	3	4′	2	3	4′	
C days			1	2	3	4′	2	3	4′

There is no simple quotidian parasite. All quotidian fevers which are not æstivo-autumnal are either double tertians or triple quartans. A rarer form of duplication is that of the double quartan which gives us two successive fever days with an intervening free day. Mixed infections of simple tertian and quartan parasites may occur, causing much perplexity to the clinician, or a mixture of simple tertian and æstivo-autumnal parasites. In the latter case the simple form soon succumbs while the æstivo-autumnal survives.

Symptoms.—A paroxysm of intermittent fever presents three stages: the stage of chill, that of fever, and the sweating stage. The chill is sometimes preceded by prodromal symptoms of general uneasiness, yawning, stretching, possibly nausea or headache. With or without these prodromes, the patient then experiences sensations of cold which soon develop into slight rigors or into a prolonged, shaking chill, which may last but a few minutes or may be prolonged for an hour or more. During this stage, when the patient is shaking with cold, his nose and finger-tips blue and his extremities cold to the touch, the fever has actually begun and the temperature under the tongue may be as high as 104° or 105° F.

The chill is followed by sensations of heat and great heat of the surface of the body, although the temperature rises no higher than before. Headache and pain in the limbs are now common. The fever stage varies in duration from an hour to six or eight hours. The termination of the fever is accompanied by more or less profuse sweating, lasting for from half an hour to two hours or more, during which stage the patient loses all his acute sufferings and quite commonly falls into a quiet sleep. On awakening he declares himself as feeling quite well, although perhaps a little weak. He continues to feel well until the onset of the next paroxysm.

Herpes labialis is quite a frequent accompaniment of intermittent fever and is of some diagnostic value because so rarely occurring in graver fevers.

Dumb Ague, as it is popularly called, is that form of paroxysm in which there is no chill, the hot stage being the first. This is more common among the older residents in malarial regions.

Sometimes an attack of intermittent fever will be so shrouded by intercurrent symptoms as to mislead the observer. There may be so much congestion of the bronchial mucous membrane, with short, difficult breathing, slight cough, fine mucous râles, and even a catching pain in the side, as to suggest the invasion of pneumonia. Violent vomiting and diarrhœa at the outset of the paroxysm may pass for a mere attack of cholera morbus. Severe pain in the back and limbs, often referred especially to one joint, which the patient is unwilling to move, crying out with pain when he does so, closely simulates rheumatism. In all such cases the unwary practitioner may flatter himself that he has been very successful in "breaking up" an attack of one kind or the other, only to find it recur in full force at the end of its appointed time.

In children under two years of age, and often in those of the age of three or four, there is no such thing as a shaking chill, and the first thing that may be noticed by the attendants is the fever. Careful observation, however, will detect the stage of chill by the fact of the lips and nails becoming blue, the nose and extremities cold, and the face pale and the eyes sunken. Sometimes the child will vomit two or three times in succession, and then it wants to go to sleep. After a little while the face grows flushed, and the surface of the body hot; the child becomes quite restless, throwing itself about in the bed; and in a certain number of cases convulsions supervene. Other children, again, pass from the cold to the hot stage without waking, but, on the contrary, fall into a profound sleep or semi-comatose condition, from which they gradually emerge during a brief sweating stage. Children are more liable to quotidian than to tertian attacks, and during the intermission they do not seem well, but are peevish, and perhaps drowsy, with a poor appetite and some disturbance of the stomach and bowels.

Pathological Anatomy.—Ordinary intermittent fever not being a fatal disorder offers no opportunity for post-mortem findings. An examination of the *blood*, however, reveals not only the presence of the malarial parasite, with its accompanying pigment, in the red blood corpuscles, but a loss of red corpuscles, sometimes very great, during the paroxysm of fever. This loss is usually, to a great degree, regained during the intermission, but few diseases cause so great anæmia as do malarial fevers, especially, of course, the prolonged forms. According to Kelsch, quoted by Marchiafava and Bignami in the "Twentieth Century Practice," vol. xix., "twenty days of fever may suffice to reduce the number of red corpuscles in a patient from five million in a cubic millimetre to one million or even less," and in pernicious infections, at the beginning of the disease, according to the same authority, "in a robust individual, in the course of one day only, the number may go from normal to one million per cubic millimetre."

There is never leucocytosis, unless it be dependent on the accidental presence of some inflammation; but, on the contrary, the number of leucocytes is greatly diminished. Pigmented leucocytes, which have swallowed the degenerated red cells with their contained parasites and pigment, are not infrequent.

The *spleen* is palpably enlarged during the paroxysm of fever, this enlargement subsiding during the intermis-

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sion. Only in chronic cases does the enlargement persist during the interval between febrile attacks. In the few autopsies reported in which death occurred from other causes immediately after an attack of intermittent fever the enlarged spleen was found not to be softened nor very melanotic, nor were the liver and bone marrow very melanotic.

The *urine* is increased in amount both during and after the fever. The specific gravity of the same is also increased, notwithstanding the large amount of the secretion, a change which is due to the absolute increase of the salts and nitrogen eliminated. In the polyuria of convalescence, especially after tertian or quartan intermittent, the amount of urine voided sometimes amounts to from four to six pints in twenty-four hours, the specific gravity still remaining increased relatively to the amount, this increase being due largely to the excess of urates and phosphates. Albuminuria is rare and hæmaturia belongs to the pernicious fevers.

Diagnosis.—The diagnosis of intermittent fever is easy, if the symptoms are at all marked, especially if we wait until the patient has gone through the intermission and entered upon a second fever paroxysm. At least this is true in a single tertian or quartan fever. It is not always so evident when, with a double tertian, for instance, we have a daily fever paroxysm, of long duration, as in those cases, referred to above, in which the access of fever is accompanied by such local symptoms as suggest some other disease, such as pneumonia. At all times it is of great value to have a blood examination made, to prove, if possible, the presence of the malarial parasite and to determine whether we have to deal with a simple tertian, a quartan, or an æstivo-autumnal parasite. To give a satisfactory result the blood specimen should be taken early, before the patient has been loaded with quinine.

Treatment. Prophylaxis.—So far as regards measures which shall change a malarial region of country into one that is non-malarial it has long been known that this could best be accomplished by the drainage of marshes or of such areas as favor the accumulation of stagnant ponds or pools. Since we know that the mosquito is the carrier of infection, it is necessary also to remove all smaller collections of stagnant water, as in tanks, barrels, etc., which might serve as the breeding places of the mosquito, or to protect them from the access of the insect. Drains, cesspools, etc., must be treated with disinfectants or with coal oil which renders them unfit for breeding places. An oily film over the surface of water containing the larva or pupa of the mosquito prevents their access to air and thus insures their death. For this purpose coal oil is found to be the most practicable as well as the cheapest material. It is amazing to note how much can be accomplished in the extermination of the mosquito, by means of drainage and the coal-oil treatment of pools and small collections of water, at no very great expense to municipalities, local governing boards, or private individuals. Among the well-known instances of this sort of work successfully accomplished are the practical suppression of yellow fever in Havana in 1901, chiefly through the labors of the "mosquito brigade," and the campaign against mosquitos, and therefore against malaria, waged by means of drainage and coal oil at Oyster Bay, Long Island, during the same year. Dr. L. O. Howard, Entomologist of the United States Department of Agriculture, has taken much pains to make public the necessary information on this subject, and before this article appears in print, the matter will already be familiar to many of its readers.

In the way of *personal* prophylaxis it is evident that the main thing, if not the only thing, is to avoid being bitten by the mosquito. For this purpose residences, whether permanent or temporary, should be located on as high ground as is practicable and away from standing water. Doors and windows should be carefully screened and people should sleep under mosquito nets.

As the insect is by far the most active toward sundown and at night, it is essential to remain indoors at those times, if possible. Prophylactic doses of quinine are also to be recommended, one or two grains three times a day. It has repeatedly come within the experience of the writer that in parties of men newly exposed to malarial influences those who took such doses of quinine escaped, while those who refused succumbed to some form of malarial attack.

Treatment during the Paroxysm.—In ordinary attacks of simple intermittent fever no treatment is required during the paroxysm, and the patient may be allowed to follow his own inclinations in the matter of being covered or uncovered, taking hot or cold drinks, having hot bottles applied to his feet, cold cloths to his head, etc. In the more severe attacks, where there is more than ordinary general prostration and distress, or the patient suffers greatly from headache, or pain in the back and limbs, it is a good plan to administer a full dose of opium during either the stage of chill or that of fever. The effect will be to alleviate the suffering, and, perhaps, to shorten somewhat the first or second stage. A full dose, forty to sixty grains, of bromide of potassium, will answer the purpose if there is not severe pain. In case there is any reason, from the previous history of the patient or the nature of his present attack, as shown by unusually high temperature (over 105° F.) or grave nervous symptoms, to fear that it may prove pernicious in character, thirty grains of quinine should be given in one dose during the cold, or early in the hot stage. A single large dose is far more effective than repeated smaller ones, and less likely to disturb the stomach and aggravate the headache.

During the Intermission.—The entire treatment of a case of intermittent fever is usually conducted during the intermission, the object of course being to prevent the recurrence of the paroxysm. In some cases in which there is a badly coated tongue with sluggish action of the bowels and clay-colored stools, it is well to begin the treatment with a few small doses (gr. $\frac{1}{4}$ to gr. $\frac{1}{2}$) of calomel every two or three hours, followed by a saline cathartic at the end of twelve or twenty-four hours, or ten grains of the Pilula hydrargyri, with two or three of compound extract of colocynth, may be given at bedtime. But it is very important that no time should be lost in this preliminary treatment to the exclusion of quinine, for the two can, to the very best advantage, be used at the same time. As soon as one paroxysm is over, it is time to begin taking quinine to prevent the next one. When the type of the fever has not been determined by the occurrence of more than one paroxysm, it is well to assume that it is quotidian and treat it accordingly.

The full effect of a five- or ten-grain dose of quinine is felt in from two to four hours after its administration. Suppose the chill of a given paroxysm to have begun at 10 A.M., and the sweating to have ceased at 6 or 8 P.M.; I should have that patient take ten grains of quinine at midnight, ten at 4 A.M., and ten at 8 A.M., and should expect thus to avert the second paroxysm, which would be due at 10 A.M. of that day. If successful in this, I should give no more during that day, but I should repeat the same programme during the second night. Having thus prevented two recurrences, I would then put the patient on five grains of quinine three times a day for a week, and after that drop to two grains three times a day, which dosage should be continued for a month, if the patient remains in a malarial region. If thirty grains in three doses did not prevent the recurrence of the chill on the day following the first paroxysm, I should mass that amount and give it either in two doses of fifteen grains each, one at 3 A.M. and one at 7 A.M., or in a single dose at 7 A.M.

No one who has tried it can have any doubt with regard to the frequent efficacy of large doses of quinine where smaller ones fail, nor is the discomfort caused by the large dose as much greater as would be supposed.

There are two plans, then, for the administration of the requisite amount of quinine during the intermission: the one to give it in five-grain doses every four hours, beginning toward the end of the sweating stage; the other to give it in two or three ten- or fifteen-grain doses at the

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same interval, but so arranged that the last dose shall come two hours before the expected attack. I prefer the latter.

Method of Administration of Quinine.—A solution of quinine is doubtless the most certain method for internal use, but is objectionable on account of its intense bitterness and its liability to cause vomiting. The most practicable and at the same time the most efficient method is to enclose the dry powder in gelatin capsules or in wafers. All ready-made pills are to be avoided, on account of their possible insolubility.

The syrup of yerba santa is the best vehicle for disguising the taste of the drug, and is therefore valuable in case of children or others who cannot swallow capsules.

When rejected by the stomach the drug may be given in enema, double the amount being used here that would be given by the mouth. I have very little faith in the endermic method, or the quinine and vaseline inunctions used by some. The hypodermatic use of quinine, however, has much in its favor. It is prompt and certain in its action, and is sometimes the only method that can be employed. The objection to its use is the considerable danger of abscesses forming at some of the points of puncture. From one-fourth to one-half of the dose ordinarily given by the mouth is required by this method.

When speaking of quinine simply, one is understood as referring to the sulphate of quinine, the salt in most common use. Other salts of the alkaloid are equally efficacious. The bisulphate is more soluble, so also is the hydrochlorate, though the latter is said by some not to be so uniform in strength. The bromide and the valerianate of quinine are preferred by some on account of the supposed benefit to be derived from their respective acids.

Next in value to the quinine salts are those of the other alkaloids of cinchona, viz., quinidine, cinchonidine, and cinchonine. Their value has been thoroughly tested by several commissions appointed for this purpose in India, the result of whose investigations proves that these are all of equal, or nearly equal, value with the sulphate of quinine. While the sulphate of quinidine is just as effective as the sulphate of quinine, when administered in the same doses, it is very apt to cause gastric distress, vomiting, and purging. The sulphate of cinchonine is effective in somewhat larger doses than quinine, but is also more liable to disagree with the stomach. The sulphate of cinchonidine produces the same effect as quinine, in doses that are twenty-five per cent. larger than those of the latter, without any disagreeable effects. I have myself had considerable experience with the cinchonidine salt, and have obtained thoroughly satisfactory results from its use in five- and ten-grain doses.

The remedy next in rank to the cinchona alkaloids in the treatment of intermittent fever, though far below them in efficacy, is *arsenic.* It is more effective in cases of chronic malarial cachexia, and is very valuable, when used in combination with quinine and iron, in all old and obstinate cases of intermittent fever. It has, however, also been successfully used alone in the treatment of acute cases, especially by some French physicians. They give as much as half a grain of arsenious acid in solution in the course of a day, during the intermission, with very good results. The same treatment has been successfully employed in India, care being taken to select patients with no gastric or intestinal irritation. It is important that the remedy be used largely diluted, and when desirable it may be combined with small doses of opium. As a rule, its action in preventing the recurrence of paroxysms of fever is much slower than that of quinine.

Prognosis.—Ordinary intermittent fever, in the early history of any given case, is probably always susceptible to cure by the proper administration of quinine. Spontaneous cures are not infrequent, the fever running its intermittent course for a week or two and stopping without medication. If such patients have ceased to live in a malarial region the cure may be permanent. If they remain in a malarial region, the fever is almost sure to return after a variable period. It cannot be too strongly insisted on that after the arrest of paroxysms of intermittent fever, the patient should continue to take quinine during the fever season, either in small doses daily or in larger doses, of ten or fifteen grains, every third day, or at the outside every week.

Masked Intermittents.—Under this head fall a variety of obscure affections, usually non-febrile in character, having a distinct periodic recurrence, and being curable by quinine. Prominent among them are periodic neuralgic attacks, usually in the form of one-sided supraorbital or infra-orbital pain, with throbbing of that side of the head; sometimes a one-sided conjunctivitis and swelling of the lids. After a few hours all these symptoms will entirely disappear, to recur regularly in quotidian or tertian form. Or the pain may be along the track of the maxillary nerves, superior or inferior, or of the sciatic or the intercostal nerves. In the latter case both patient and physician may suspect pleurisy, and flatter themselves that they have cured it, until, on the second or third day, it promptly recurs.

Many other nervous disturbances, as choreiform seizures, temporary paralyses, etc., occur with periodic regularity in malarial regions, and yield to treatment by quinine. Although some authors protest against it, the conclusion is very natural that such attacks are of malarial origin. I have myself seen, in a young man, a well-marked case of amnesic aphasia which occurred regularly on the afternoon of every other day for three successive times, after which he was put on ten-grain doses of quinine, three times a day, without any further recurrence of the trouble.

In all such cases, and many others that cannot be here enumerated, the entire absence of all symptoms during the greater part of the time forbids the thought of any organic lesion, while the regular periodic recurrence of these symptoms, and the fact of their yielding to antimalarial treatment, afford proof of their malarial origin.

At least this was proof enough before we knew anything about blood examinations for the malarial parasite. To-day no one would consider such a diagnosis unequivocal without the aid of the microscope, and it is quite probable that, by means of blood examinations, many maladies heretofore believed to be malarial may be shown not to be such.

Irregular, Remittent, or Continued Fever; Æstivo-Autumnal Fever.—All observers, from the earliest period, have recognized a variety of malarial fever which differed from the ordinary intermittent type, being characterized by longer continuance of the fever paroxysms, with remissions rather than intermissions. This form is more grave, more likely to be long-continued and refractory to treatment, and more fatal. Parasitologists generally agree that this form of fever, in all its varieties, is due to the presence of the æstivo-autumnal parasite. In this class are also embraced the pernicious fevers which are not long-continued, and which have always been known, in many instances at least, to have a distinctly intermittent character. We used to class pernicious fevers among the intermittents, but now they are reckoned as æstivo-autumnal. There is abundant evidence that any of the fevers caused by the æstivo-autumnal parasite may, at least in their earlier history, be intermittent instead of remittent, taking on later the remittent or continuous type. Many authors assert the existence of a quotidian and a tertian variety of the æstivo-autumnal parasite. Others make different and more numerous divisions, but there is practical unanimity as to the species. This element of intermittence in fevers caused by the same species of parasite that gives us a remittent or continued fever brings great confusion into our terminology, which will have to be recast, on the basis of the findings of the microscope, whenever parasitologists are agreed and they and the clinicians can come together.

For the present we must content ourselves with remembering that ordinary intermittent fever due to the larger, simple, tertian or quartan parasite, differs essen-

tially from the æstivo-autumnal intermittent which is liable to run into the remittent or continued fever.

Probably as good a classification of æstivo-autumnal fevers as we can give at present divides them into: (*a*) the irregular intermittent fevers, with long fever paroxysms which have a tendency to approximate and run into each other, thus giving continuity; (*b*) the continuous or remittent fevers, which often begin with a chill but are not characterized by repeated chills, and which are often accompanied by symptoms of gastric disturbance and slight icterus, the fever continuing, with remissions, for a period of two or three weeks, or even longer; and (*c*) the pernicious fevers, which may be intermittent and which either prove rapidly fatal or soon yield to treatment.

(*a*) The first form is not common in this country and will not be dwelt on, although it is important to bear in mind its existence. It yields, with reasonable promptness, to vigorous treatment. The great importance of having recourse to blood examinations by a competent microscopist, to determine whether, in such cases, we have to deal with an æstivo-autumnal infection, lies in the fact that we have here a much more grave disorder than a simple intermittent *and one which is liable to end in a pernicious attack*, perhaps terminating the life of the patient. Hence the imperative demand for an early diagnosis, which can be made unequivocal only by a blood examination. If, then, the patient is living in, or has just come from, a region where pernicious fevers prevail the most vigorous treatment is demanded to prevent the possibility of a pernicious paroxysm.

(*b*) The second class of æstivo-autumnal fevers consists of that form which we have been accustomed to designate as *remittent malarial fever*, and which has also been called "bilious fever," "gastric fever," etc.

The *pathology* of æstivo-autumnal fever of both the first and the second class, when not pernicious, is practically the same as that of ordinary intermittent fever, due allowance being made for the difference in form of the two species of parasites, and for the greater tendency of the red corpuscles containing æstivo-autumnal parasites and of the leucocytes containing both red corpuscle and parasite to mass themselves in internal organs. The essential lesion is the blood lesion, with its profound anæmia, its melanæmia, its enlarged and pigmented spleen and liver and other organs. In the more prolonged and graver attacks of this class the lesions, in individual organs, will more nearly resemble, or be identical with, those described under the head of pernicious fevers.

Symptoms.—The onset of remittent fever is usually abrupt, commencing with a chill of moderate intensity. If there are prodromal symptoms they will consist of lassitude and general malaise for a day or two, with headache and perhaps pains in the limbs and back, loss of appetite, a foul taste in the mouth, and sometimes nausea. The chill is not so prolonged nor so violent as in many cases of intermittent, lasting perhaps for half an hour or less, and followed by fever in which the temperature will range from 101° to 103°, or even 105° F., remaining for many hours at or near the highest point reached. It is not unusual for bilious vomiting to occur during the chill and during the first few hours of the fever, and in such cases there is often considerable irritability of the stomach for several days. The fever will continue without any marked remission for twelve, twenty-four, or forty-eight hours. During this time there are complete anorexia, sometimes great restlessness and vigilance with continued headache, sometimes a persistence of the vomiting; but more commonly these symptoms subside and the patient is drowsy.

The remission is marked by an amelioration of the distressing symptoms, if such have existed, and a fall of temperature to about 100° F. This may continue for from three to six or twelve hours, occasionally even being prolonged to twenty-four or thirty-six hours. If the attack is not severe, the patient will declare that he feels quite well, and will wish to get up. His appetite, however, does not return, and he is far from feeling as well as during the interval of a quotidian intermittent, for instance. At the appointed time the fever rises again, gradually reaching its former, or a still greater, height. This rise is seldom accompanied by a repetition of the chill.

From this time on, if the progress of the disease is not arrested, there will be periodical remissions and exacerbations, usually occurring once or twice during the twenty-four hours, but sometimes at more prolonged intervals.

At the beginning of an attack of remittent fever the tongue will be furred, of a gray or yellowish tint, large, moist, and indented by the pressure of the teeth. Later, it is likely to grow dry, smoother, and brownish in the centre, red at the tip and edges, with sordes on the teeth. Nose-bleed is not very uncommon. The stomach may be irritable throughout the attack.

The bowels are usually constipated, the urine is scanty, high-colored, and acid.

The skin and the whites of the eyes often show a yellowish or jaundiced hue, especially in those persons who have lived long in a malarious region.

There is no petechial eruption. It is not unusual to see an outbreak of herpes about the mouth.

Delirium is not common in the simple remittent, but in the graver, more protracted form it often occurs, accompanied with the other symptoms of the typhoid state, such as dry, cracked tongue, sordes, subsultus, etc.

The course of the disease varies greatly in different cases. In the most favorable, under vigorous treatment, it is arrested in from three to five days. In severer cases the course is more protracted, running from two to three or four weeks, or even longer. Such cases present very varying degrees of gravity. In some of them the patient makes very little complaint, does not look very ill, eats and sleeps quite well, while still the temperature remains at from 100° to 102.5° F., and the patient grows quite weak. In others, with but a slightly higher range of temperature, there will be great gastric irritability or severe headache, great restlessness and vigilance, and many, though not all, of the symptoms of typhoid fever, such as dry, cracked tongue, sordes on teeth and lips, and muttering delirium. This is the "typhoid state," which may also occur in other diseases than specific typhoid fever or grave malarial remittent fever, and these are the cases which used to be reported as "typho-malarial fever." There is, however, no characteristic typhoid fever temperature in the first two weeks, no rose-colored rash, no marked iliac tenderness, or gurgling; as a rule, no tympanites or diarrhœa.

The simple form, when not arrested by suitable doses of quinine, runs its course in from ten days to three weeks without any alarming symptoms.

Diagnosis.—While in the majority of cases a reasonably positive diagnosis can be made from the environment of the patient, the prevalence of malarial infection at his place of residence or at some place which he has visited, together with the history of the attack, it still remains true that for an unequivocal diagnosis recourse must be had to a blood examination and to the demonstration of the presence of the æstivo-autumnal parasite. In order to make this test reasonably certain, however, it should be applied before the administration of quinine. Therefore we often prefer to prove the correctness of our diagnosis by the success of the treatment.

When it is necessary, as is frequently the case, to differentiate between remittent malarial fever and *typhoid fever*, we have, on the one hand, the demonstration of the malarial parasite, and, on the other hand, at a proper stage of typhoid fever, the *Widal test*, as our criteria. With these two aids, whenever the services of a competent microscopist can be secured, the diagnosis should not remain doubtful.

The differentiation from *yellow fever* calls still more imperatively for a blood examination, since the malarial parasite does not exist in yellow fever. Furthermore, in the latter, jaundice occurs early and is more intense, bleeding gums and black vomit are prominent, while

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very rare in malarial fever. The enlarged malarial spleen is wanting in yellow fever.

Treatment.—In remittent or æstivo-autumnal fever, as in all forms of malarial disease, quinine is our sheet-anchor. No time should be lost in preparatory treatment. Whatever else needs to be done may be carried on at the same time, but the first requisite is to put quinine enough into the blood to arrest the development and multiplication of the parasite. Seven-and-a-half to ten-grain doses of quinine every three or four hours until thirty or forty grains have been taken during the twenty-four hours, or fifteen-grain doses every eight or twelve hours will often cut short a remittent fever in the first two or three days. If this happy result does not follow, the same treatment, slightly modified according to circumstances, should be continued for a week. The disagreeable nervous disturbances of cinchonism may be to some degree modified by full doses (thirty or sixty grains) of one of the bromides. Sometimes an irritable stomach rejects the quinine. This irritability may often be quieted by counter-irritation over the epigastrium, as by means of sinapisms, by the administration of calomel and soda triturates, or of broken doses of Seidlitz powders or other effervescent draught.

If the stomach is utterly rebellious we may try the rectum, rubbing up double the amount of quinine we would use by the mouth with a little yolk of egg and tepid water and using it by enema.

If neither of these methods succeeds, or in any event if the case be urgent, as in pernicious fevers, we must resort to the hypodermic use of the drug. Thirty grains of bisulphate of quinine with five grains of tartaric acid in two drachms of water makes a good solution, one-half of which may be given at a time. Heat alone will dissolve five grains of any quinine salt in thirty minims of water. If this is quickly used in a well-warmed hypodermic syringe no added solvent will be required. Hypodermic quinine is somewhat liable to cause a puncture abscess, but in a grave emergency this is not to be taken into the account.

If by means of such vigorous treatment an attack of æstivo-autumnal fever is brought to an end, the quinine is by no means to be withdrawn. Not less than five grains every four to six hours should be continued for a week, and after that two or three grains three or four times a day for at least two weeks longer.

In the treatment of these fevers, after the subsidence of the acute attack, which may have been accomplished by the use of quinine within the first week, there are no more valuable remedies than arsenic and iron used in combination with the continued quinine treatment above indicated. A liberal, blood-making diet is called for, and, if possible, an escape from the climate or the surroundings in which the malarial infection was acquired.

Other symptomatic treatment, both early and late, will be employed by the intelligent practitioner, according to the indications. But the great thing to remember is that no treatment of "biliousness" by mercury, nor of fever by antipyretics, nor any other treatment, not even change of climate, will accomplish the purpose unless accompanied by the use of suitable doses of quinine.

Medical men who have practised for years in malarious regions have heretofore been divided into two classes: one class believing that every continued fever which did not yield to quinine was typhoid fever; the other class holding that there were cases of continued malarial fever which would not yield to quinine. It seems probable, under the revelations of the microscope, that the second class will have to surrender their belief, without, however, granting the claim of the first class that all such cases are typhoid fever. Marchiafava and Bignami ("Twentieth Century Practice," vol. xix., p. 418), say: "Physicians should rid themselves of the notion of the prolonged and obstinate resistance of typhoid-like, subcontinuous malarial fevers to quinine. When quinine is properly administered, the fever is not prolonged more than four, five, or six days." On the other hand, however, on page 300 of the same work, these authors say: "In a detailed study of æstivo-autumnal fevers we shall see how, in malarial seasons and climates, *infective fevers occur whose etiology is not yet known*, and which, without an examination of the blood, might, even at the present day, be confounded with diseases of malarial origin."

(*c*) *Pernicious Fever.*—This form is rare in the temperate zone, although it may occur even there in newly settled regions. It is common in the tropical zone and frequently met with in sub-tropical countries. Although caused by the æstivo-autumnal parasite, pernicious attacks are not seldom distinctly intermittent, a period of twenty-four or forty-eight hours intervening between the paroxysms.

In the majority of instances there are no prodromal symptoms of the pernicious attack, but it either strikes the patient like lightning out of a clear sky, or else it follows a few lighter intermittent paroxysms.

The most common form of pernicious fever is the *comatose* or *apoplectic* form. This is rather more liable than some of the other varieties to be preceded, during the intermission, by drowsiness, hebetude, or severe headache. The chill may be more or less complete. During the hot stage the patient falls into a stupor or coma. He lies there with flushed face, pupils dilated and fixed, breathing stertorous, pulse sometimes fast and sometimes slow, muscles completely relaxed, skin dry and hot, temperature in the axilla 104° or 105° F.

This may last for six, twelve, or twenty-four hours, sometimes even for several days, the pulse and vital forces failing until the patient quietly ceases to breathe. Or at the end of a certain number of hours he may gradually rouse himself, confused in his ideas, still complaining of headache, perhaps even confused in speech, and with paresis in some one of his extremities, all these symptoms, however, gradually disappearing during the intermission.

Instead of pursuing the course described above, the coma may be preceded by violent delirium, even mania. Or the delirium may end in sudden collapse and death, or in sleep and recovery without the supervention of coma. Again, in other instances there will be nervous manifestations showing the involvement of the spinal cord as well as brain, such as clonic or tonic forms of spasm, of the eclamptic, epileptic, or tetanic variety. The more varied and violent the forms of nervous disturbance the more unfavorable the prognosis.

Two forms of attack, which are found especially in tropical climates, are the *choleraic* and *dysenteric*. In the former there are burning thirst, severe vomiting, watery stools, cramps in the calves of the legs, finally collapse, and death with all the signs of asphyxia. In the dysenteric form serous, mucous, and bloody stools occur during the paroxysm, and disappear during the intermission. The *algid form* may or may not begin with a chill and have a fever stage. Either following a rise of temperature or without it, the body temperature falls below the normal, even going as low as 90° F. The patient often complains of burning heat within and of great thirst. The skin is pale or livid, the pupils are dilated, the pulse is feeble and may be irregular. Consciousness is retained to the last, and the patient is strangely indifferent to his surroundings and his danger. Sometimes the choleraic and algid forms are combined. The urine is diminished in amount and may even be suppressed. This general condition may continue for several days with an occasional rise of temperature to normal or even to 100° F. or more, and the patient may then die.

This form of pernicious malarial attack seems to justify the popular term of *congestive chill*, so common in all malarial countries, although the name is often given by physicians, as well as by the laity, to any extremely severe or pernicious malarial attack.

In all the pernicious forms death may occur in the first paroxysm, within the first twenty-four hours, or there may be a fall of temperature with great, if not complete, amelioration of all the symptoms. Unless prevented by treatment, the paroxysm will, however, return at its appointed time, probably with increased severity, and in

the second or third attack the patient will perish. Other cases, not marked by intermissions, run a more continuous course for several days before the fatal termination or gradual recovery. The writer, many years ago, when the neighborhood of Kansas City was quite malarious, witnessed a number of deaths from pernicious fever, chiefly of the comatose form. One woman, after three or four apparently simple intermittent attacks during the week, for which she had taken small doses of quinine, fell into the most profound coma and lay in that condition for seventy-two hours. She was "as yellow as gold"; the insensibility was so great that the conjunctiva could be touched with impunity; the pupils were moderately dilated and fixed; the breathing was slow and stertorous; the urine, drawn by catheter, was very scanty, loaded with urates but not albuminous; the bowels were not to be moved by enemata nor by means of the calomel given her; it was almost impossible for the patient to swallow anything; the surface of the body was hot and dry, the temperature in the rectum remained steadily at from 105° to 106° F.; the pulse was slow. In spite of her apparently hopeless condition, under the persistent hypodermic use of quinine and whiskey this patient rallied and finally recovered.

Pathological Anatomy.—In addition to the blood changes found in all forms of malarial infection the pernicious forms give some tolerably well-marked local lesions. In the comatose form the leptomeninges are intensely hyperæmic as is also the cerebral substance, besides being very melanotic. Punctiform hemorrhages into the white substance are common. The endothelium of the capillaries is often swollen and in a state of fatty degeneration, the lumen of the vessels being closed by the swollen endothelial cells. In other cases there are actual thrombi of pigment matter, free parasites, and parasite-laden corpuscles. The same changes have been found in the spinal cord. The conditions in the spleen and liver are exaggerations of those found in malaria generally, the spleen substance is softened, the liver may present small areas of necrosis. In the choleraic form of fever the mucous membrane of the stomach and small intestines is swollen and of a dark-red, sometimes chocolate color. The capillaries of the mucosa are filled with parasites and sometimes its tissue, especially in the villi, is the seat of a superficial but extensive necrosis. Thrombosis of parasites and phagocytes in the intestinal capillaries is not uncommon.

Treatment.—The treatment of pernicious attacks is the same as that of remittent fever, except that there is more urgency in the former and more vigorous interference is demanded. The early recognition of æstivo-autumnal intermittent paroxysms, by means of blood examinations, should so put the practitioner on his guard as to enable him to forestall the graver seizure. When the attack is on, the important points are, first, not to mistake it for ordinary apoplexy or cholera, and, second, to begin early with full doses of quinine, hypodermically, and to keep this up to the last, no matter what else is done, even under the most discouraging circumstances.

Tropical Malaria does not differ, in kind, from the malaria of more temperate regions. The severe, frequently fatal malarial fevers of Panama or West Africa, which sometimes take the pernicious forms described above and sometimes drag out a longer and more continuous course, are found to depend on the same æstivo-autumnal parasite as the milder fevers of more temperate climates. An admirable work on æstivo-autumnal fevers by Charles F. Craig, Acting Assistant Surgeon, United States Army, published in 1901, gives many points of interest with regard to these fevers as occurring especially in Cuba and the Philippines and the blood conditions found in soldiers who have returned from the Philippines.

Malarial Cachexia.—This is a condition very often met with in malarial regions; sometimes in those who have suffered with innumerable paroxysms of intermittent fever, sometimes in those who have never had a chill, but have long been subjected to malarial influences.

Persons so affected may complain of every imaginable symptom known to medicine, but they will almost all agree in the following: loss of appetite, a bad taste in the mouth, indigestion, a constant sense of weariness, unrefreshing sleep, dragging pains in the loins or small of the back, shortness of breath on exertion, and vague pains in the joints or muscles of the extremities. Such persons are usually more or less emaciated, pale, and sallow. The pulse is a little rapid, there is no elevation of temperature, and generally there is nothing periodical about the case. The spleen is greatly enlarged, hard, and somewhat tender on pressure, or may even be spontaneously painful in certain positions of the body, or after lying in one position for some time. In leukæmia there is also an enlarged spleen, although not so hard, and in malarial cachexia there is no increase in the number of white blood cells, so characteristic of leukæmia. In addition to the presence of malarial parasites, especially in the blood of the internal organs, the most striking lesion in malarial cachexia is a profound *secondary* anæmia which may readily be distinguished from an essential or pernicious anæmia by a blood examination. In the severer forms the sallowness is greater, amounting to actual jaundice, the urine is scanty and often icteric, the bowels are irregular, the abdomen is often greatly distended, and finally there may be œdema of the face and extremities, while the general feebleness of the individual and his cachectic appearance are most marked.

Much more might, and perhaps should, be said on this subject, but I must content myself with only a few words concerning treatment. Many such cases still need quinine along with their other treatment, but most of them will be found to have lived on this drug for years, as well as to be thoroughly familiar with the domestic use of calomel or blue mass, and various cathartic "liver pills." They will, however, be greatly benefited by the judicious administration of arsenic in ordinary, not in antiperiodic, doses, combined with iron and nux vomica, or by the use of the mineral acids, especially the dilute nitro-hydrochloric acid. Iodine preparations also do them good for a while. Care must be taken to aid the digestion, and to insure a sufficiently varied and nourishing diet. Above all things, if possible, such people should be induced to move away, even if only for a time, and if only for a short distance, from the place where they have become thus contaminated with malaria.

Edward W. Schauffler.

MALARIN, acetophenone phenetidin citrate ($C_6H_4.OC_2H_5.N.C.CH_3.C_6H_5.CH_3$), is a condensation product of acetophenone and paraphenetidin, and is a crystalline insoluble powder of acidulous taste. As another of the phenetidin combinations, malarin resembles phenacetin in its antipyretic and antineuralgic properties, but Erdmann reports it as dangerous on account of the untoward effects of acetophenone. The dose is stated to be 0.3 to 1 gm. (gr. v.–xv.). *W. A. Bastedo.*

MALIC ACID.—($C_4H_6O_5$.) An organic acid widely distributed among plants, especially in fruits, and more especially in those related to the apple. It occurs in odorless and colorless crystals, deliquescent in the air, freely soluble in water, and of a pleasant acid flavor. Its general properties are much like those of citric acid. It has been very little used. *Henry H. Rusby.*

MALIGNANT GROWTHS, THE STARVATION OF.—The attempt to control the advance of cancer and sarcoma by depriving them of blood supply is not a new thought. Ligation of the chief vessels, for this purpose, has not infrequently been tried in instances in which the growth is too far advanced to permit of extirpation. The carotid system seems that best adapted to test the principle. In 1878 Dr. John A. Wyeth, of New York, collected and analyzed all the cases then obtainable of ligation of the carotids, and he claimed that a large number of malignant tumors had thus been cured. But a careful study of these cases and his own clinical experi-

ence confirm the writer in the belief that by ligation of the nutrient artery alone tumors of this class are never permanently checked in their advance. They appear for a few weeks to cease growing, but after this brief interval of time they again resume active development.

Some idea of the difficulty of shutting off the blood supply of any part fed by arterial branches of the carotid system may be gained by simply considering how many of the eight branches of the superficial carotid freely intermingle blood with other arterial systems—*e.g.*, that of the internal carotid and that of the subclavian.

In order to overcome the difficulties just referred to and to secure a more permanent anæmia of the new growth which it was hoped in this way to subdue, the writer, about seven years ago, began his search for some method which would effect these results. The idea of completely extirpating the external carotid then first suggested itself. It was feared, though, that if this plan were carried out, the patient might lose his nose, tongue, or some other part through sloughing. In order to obtain more light upon the effects of such a serious interference with the blood supply of the head and neck, the writer made repeated trials upon dogs; tying the external carotid first upon one side of the neck and then upon both sides. As a result of these experiments one fact became perfectly clear, viz., that the normal tissues can continue to live even when supplied with a surprisingly small amount of blood—an amount much smaller than that which is required by so vascular a thing as a malignant tumor, if it is to continue growing. In no instance, during these experiments, did any normal part thus deprived of a large share of its usual nourishment undergo sloughing.

The first opportunity for testing the matter upon a human being presented itself in June, 1895. The patient, who was affected with a round-celled sarcoma of the naso-pharynx, had previously been subjected by me to a simple ligation of one external carotid. On the occasion of which I am now speaking I excised the external carotid of the other side. A rapid shrinking of the tumor followed this operation, and for a period of several months the shrinkage thus gained persisted. In the following January, however, I was compelled—as the tumor had again begun to grow, and as the patient would not permit me to excise the carotid which had previously been ligated—to excise the superior maxilla, in order to remove what I could of the tumor.

Since the date named above I have had the opportunity of testing thoroughly the safety and the beneficial effects (upon malignant growths in this region) of a *complete extirpation of both external carotid arteries.* The operation has now been performed in over eighty cases (over forty of them by myself). Among those who have performed it may be named: Drs. Keen and Da Costa, of Philadelphia; Drs. Weir, Brewer, Bristow, Blake, Johnson, Meyer, Erdmann, Gibson, Collins, Lilienthal, and Woolsey, of New York; and Nicolson, of Atlanta, Ga. All of these operators agree in the statement that the operation presents no special difficulties. Upon an average a half-hour easily suffices to complete the carotid excision upon one side of the neck. If the operation is properly done, the loss of blood is almost *nil;* and hence the danger is so slight that, were not many of these patients already advanced in years and cachectic from having a malignant growth too far advanced to warrant its ablation, the mortality from the operation might rightly be expected to be insignificant. As it is, we may estimate it roughly, for cases in which there are no complications such as adherent masses of diseased lymph nodes, or in which no attempt is made to remove the tumor itself, at from one to two per cent. In no case yet reported has the pulse ever returned in any of the branches of the excised carotids—a result in striking contrast, as to permanency of the anæmia, to the speedy return of pulsation always observed after double ligation of the same vessels. In Zuckerkandl's "Operative Surgery," Dr. Da Costa, the American editor, states (2d edition, p. 48) that he has verified my observation that the shrivelling of the malignant growth which follows extirpation of the artery is greater than it is after mere ligation.

Technique.—The external carotid is exposed from end to end. The incision in the skin is made fully 2 cm. nearer the median line of the neck than commonly is taught; this being a gain in both safety and speed of work. A ligature is passed about the external carotid, close to its origin, but is not yet tightened, as it is easier to expose and recognize its branches when large, being full of blood, than when collapsed and reduced to mere threads. Each branch, in order, from below upward, is tied twice, as far from the carotid as possible, and divided between the ligatures. The veins draining the same regions are also treated similarly, in order to increase thereby the difficulty of restoring anastomoses. When all but the terminal two branches are controlled, the parent trunk is tied twice and cut, as near to its origin as seems safe. The distal stump of the external carotid is now made to dive beneath, and reappear above, three structures: the twelfth cranial nerve, the posterior belly of the digastric, and the stylo-hyoid muscle. By this manœuvre the work of reaching the terminal two branches—the internal maxillary and the superficial temporal, buried in the parotid gland—is facilitated; and by stretching the gland tissues surrounding the end of the external carotid with the jaws of a slender pair of dressing forceps, the artery is freed and its bifurcation exposed. In this way the danger (incident to the use of the knife) of establishing either a facial paralysis or a salivary fistula is avoided. In some cases, by drawing down firmly upon the carotid terminal stump, we can slip a ligature over this vessel high enough up to shut off the supply of blood to the branches just named. Usually, however, we can tie off only the external carotid just below them.

Results.—These have been encouraging; in sarcoma, surprisingly so. Several cases of subperiosteal and extremely malignant sarcoma—of the sort deemed practically hopeless by Butlin—have now remained shrunken far beyond the three-year period of Volkmann, after which we may with less hesitancy claim permanency of results. The tumor, it is of course understood, does not wholly disappear. It is, as we assume, too large to be cut out, or it is so placed that this is not practicable; but, by the plan here advocated, it is caused to undergo great shrinking and then remains inactive. Furthermore, the operation is not a deforming one. Only two thread-like vertical lines, one on either side of the neck, remain to indicate that any surgical work has been done. As to carcinoma, the results are less strikingly good. Nevertheless, we may confidently expect that the operation will, in every case, add several months, perhaps even a year, to the patient's lease of life. It should be remembered, however, that only the very worst—the most advanced and hopeless—cases have been thus far subjected to this plan of treatment. If we consider the nature of sarcoma as contrasted with that of carcinoma, we shall be able to understand why this plan of attack by starvation should be more successful in the former disease than in the latter. In sarcoma the growth depends for its extension chiefly upon the blood-vessels; the lymphatics commonly are not involved, sometimes they even stop at the surface of the tumor. In carcinoma, on the other hand, extension occurs mainly through the medium of the lymphatics. Lack of space prevents amplification of this important subject.

About eighteen months ago (in April, 1901) Dr. Wyeth suggested to the writer the idea that perhaps it might be of value either to replace excision of the carotid, or to supplement it, by injecting into the lumen of the vessel, and into that of its branches, boiling water, to cause an obliterating endarteritis; or else to inject some plastic material which, upon setting, will permanently obstruct the calibre. In following up this suggestion I have spent months of time and experimentation upon dogs and cadavers, and I have even applied the principle in a few patients. Dr. Bristow, of Brooklyn, N. Y., and the writer are the only surgeons who have, up to the present time, made use of it in actual practice. Briefly, it

may be said that to inject all the branches of the external carotid is not a safe procedure. Thus, for example, if in dogs the superior thyroids are plugged, they permanently lose the use of the vocal cords. If the linguals are plugged, the tongue either sloughs or at best it can no longer be moved at all. Hence, when the act of swallowing is performed, this organ fails to push back the epiglottis, as it should, the entrance to the larynx is left uncovered, and food, drink, and saliva then enter the air passages, often giving rise to a fatal pneumonia due to the entrance of foreign matter (*Schluckpneumonie*). Obstructing the posterior auricular artery causes sloughing of the ear. We must remember that the normal tissues demand some blood in order to live. However, it does seem to the writer worth while to try this idea, very cautiously, upon those three branches which chiefly anastomose with outside systems—the occipital, and the two terminal arteries in the substance of the parotid—and then to excise the external carotid as usual. At the same time I am convinced that the use of boiling water in the manner suggested would be likely to end fatally, either through the establishment of multiple venous embolisms, or perhaps by producing serious shock. But both Dr. Bristow and I have tried successfully a mixture, which I suggested, of one part of hard white paraffin and nine parts of white vaseline. This remains solid at or below 108° F. If injected at say 125° F., it will not set, if the work be done expeditiously, before its completion. In the full-sized adult, with blood-vessels of ordinary capacity, not more than 1.5 to 2 c.c. of this mixture should be injected distally into the external carotid at a point say from 2 to 3 cm. below its entrance into the parotid gland, thus obstructing its two terminals and preventing a renewal of blood supply through the internal carotid system; and from 2 to 4 c.c. may be injected into the occipital at its point of departure from the external carotid. Upon reflection it will readily be recognized that although time may prove this particular method of injection a valuable addition to the technique of vascular extirpation, through its power to effect an anæmia of a somewhat more permanent character, yet so far as obstructing the internal maxillary and the superficial temporal arteries is concerned, an overdose would certainly be most perilous Running like any fluid in the direction of least pressure, the mixture would enter not the capillaries of those arteries (if too much were thrown in) but first their free anastomoses. For example, the infraorbital, or main continuation of the internal maxillary, would empty the excess of the paraffin mixture into the ophthalmic branches of the internal carotid. Here, if yet a little more should be injected, the arteria centralis retinæ would be plugged (blindness); and, if still more should be thrown in, the vessels at the base of the brain would be filled,—with a prompt death from respiratory failure! Obviously, such a weapon calls for caution in its use. Nevertheless, we are fighting a savage enemy that grants no quarter, and therefore serious measures are abundantly justified. Besides, the operation is the patient's *dernier ressort*. The dose recommended above has more than once been safely injected upon the human subject by both Dr. Bristow and by myself. But experiment upon the cadaver proves that a much larger dosage would be unsafe.

Recently, the Roentgen and the Finsen rays and Coley's antitoxin injections have each given us remarkably hopeful results in certain cases of malignancy. But, unaccountably as yet, there are instances which do not yield to any of these means. For such as these it is well that the profession should know that the limit of our armamentarium has not been reached, and that in the carotid region the starvation plan is abundantly worth a trial. Within the brief compass of this article we can but outline the subject. For fuller details the reader is referred to the author's Gross Prize Essay upon the "Starvation of Malignant Growths," published in 1902 by the F. A. Davis Co., of Philadelphia. *Robert H. M. Dawbarn.*

MALIGNANT JAUNDICE. See *Liver, Diseases of: Acute Yellow Atrophy.*

MALIGNANT ŒDEMA. See *Gangrene. (Surgical.)*

MALIGNANT PUSTULE. See *Anthrax.*

MALPRACTICE.—Medical malpractice is usually understood to mean bad or unskilful practice on the part of a physician, surgeon, dentist, or midwife, when, as a result of such bad practice, death ensues or the patient's health or efficiency is impaired. Malpractice may be wilful, negligent, or ignorant, and either criminal or civil suits may be brought. As a rule, criminal suits for malpractice are brought only in cases of criminal abortion, or when a physician or other individual gives some drug or performs some operation which is contrary to law. He may perform an unlawful operation, or one which is in itself lawful in proper hands or under proper conditions. Civil suits for the recovery of damages on account of injuries supposed to have been experienced as a result of wilful negligence or ignorance on the part of a practitioner are much more common.

The responsibility of a physician or surgeon should be clearly understood, and while the rulings of the courts of various States and countries differ materially, they are fairly well set forth and may be, as a rule, easily followed. Unless there is proof to the contrary, it is assumed by the courts that no contract was entered into, and, provided reasonable care, skill, and diligence are used, the practitioner may not be held responsible for the result; in other words, it is generally understood that the physician or surgeon does not guarantee either a cure or any definite result, but he is expected to use his best endeavor to accomplish a favorable result.

Malpractice may be either active or passive. Negligence which allows the death of a patient from failure to control a hemorrhage, or to furnish other suitable emergency treatment, is as reprehensible as a more active malpractice which brings about that death by causing a hemorrhage through carelessness or negligence in operating. Errors of omission are as great as those of commission, but the former are apt to be less harshly judged than the latter.

The physician, surgeon, or other practitioner, when called upon to treat a case, is expected to exercise reasonable and ordinary skill, care, and diligence, and it is usually held by the courts that this is sufficient, provided he is possessed of and uses that amount of knowledge and skill which might reasonably be expected from one engaged in similar practice in the neighborhood in which he lives. By this ruling the general practitioner in a small country town, living far from the centres of population and medical education, is not expected to possess or to exercise as much knowledge and skill as would be expected from a specialist in one of the large cities near the centre of medical education. He is, however, bound to exercise the average degree of skill possessed by persons of his profession in his location. It must be remembered that this does not necessarily mean the average skill of the whole number of practitioners in his district, for a considerable number of such practitioners may be of extremely low grade, while, on account of education and experience, he might well be expected to possess a much higher degree of intelligence. It must be the average skill of those living in his district and under his conditions. In Pennsylvania it has been held by the courts that "such a degree of skill is required as a thoroughly educated surgeon ordinarily employs"; in the majority of the other States, however, the position taken is rather that which has been before described.

While the professional man is supposed to exercise his best judgment and skill, it is not supposed that he is infallible, and it is appreciated that errors in judgment may be made even by the best and most conscientious, and no one will be held responsible for such errors provided ordinary and well-established lines of diagnosis and treatment are followed.

If the methods of diagnosis and treatment are unusual and differ from those which are commonly accepted as proper and well established, he may be held responsible

for bad results following such unusual methods. For this reason new or unusual methods should not be attempted unless one is prepared to withstand criticism if the results are not all that might be expected. If such new or unusual methods are to be used, the patient, or his representative, should be informed that such is the case, should thoroughly understand the reason for such changes from well-established lines, and should agree to their use. It probably would be acknowledged by the courts that progress in medicine and surgery depends upon modifications in methods, and if such modifications are reasonable and based upon sound premises, it is probable that judgment would not be very severe.

Conditions may be such that a greater amount of skill would be expected from the medical man or surgeon who has been called from a distance than from those practitioners who live in the district in which the case occurs. In such cases, where a specialist from a large city is employed, he would be judged by the methods employed in the community from which he came. He may use methods which are not common where the patient is located, but he will be expected to have and use that degree of skill and knowledge which might reasonably be demanded from those having like opportunities.

When a contract has been entered into by which a cure, or some definite result, has been pledged, the practitioner will be held responsible for the fulfilment of such a contract.

Gratuitous services do not exempt the practitioner from action for malpractice if either ignorance or carelessness in his attendance can be proved. The trained physician is expected to use the same care and diligence in the treatment of charity cases that he does in those from which he receives a large fee. This does not mean, however, that in cases in which advice is sought and given, responsibility for the result is involved if the person whose advice is asked is not a professional and does not claim to have the knowledge of one. He will not be held responsible for bad results if he has given as good advice as might reasonably be expected from one in his position.

Consultations.—Cases frequently occur in which, on account of lack of experience or for other reasons, physicians feel themselves incompetent properly to diagnose or treat a given case. When this condition exists, it is the duty of the physician to call in consultation with him some other more fitted than he to judge in this particular case, and, if he appreciates that this condition exists, then he is responsible if he fails to do so. Such rulings follow the lines already mentioned by which he is expected to use due care, diligence, and skill in cases in which new or unusual methods of diagnosis or treatment are employed. When capital operations are performed, it is always safer, and usually wiser, that a consultation should be held, and the consultant who is called should be, if possible, one who is recognized as particularly well fitted for judgment in such cases.

Contributory Negligence.—When it can be proved that the patient refused to carry out the physician's instructions or failed to exercise due care, the physician or other practitioner is relieved from any responsibility which may follow as a result of such negligence. The practitioner is supposed, however, when giving instructions or outlining the treatment, to consider the personality of the individual and his surroundings, and only such instructions should be given as it is possible to follow out.

When a medical practitioner has recovered compensation for his services through the courts, such recovery will interfere with any future suit for malpractice on the part of the patient. Partners in medicine or surgery are held jointly liable for malpractice by any member of the partnership.

Summary.—A practitioner of medicine or surgery will be guilty of malpractice when serious results follow on account of his gross ignorance or neglect; when he uses medical or surgical methods that are prohibited by law; when he makes use of unusual methods which are apt to endanger the life of his patient; and when he neglects to use such means as may be necessary for the safety of his patient. He is liable for any bad result which may depend upon a want of knowledge or lack of care on his part. He is required to exercise the amount of skill which can reasonably be expected from one under his conditions. Gratuitous treatment does not relieve him from responsibility for the result. He cannot be compelled to assume the care of any case unless he so wishes; but, having accepted it, he cannot withdraw without giving suitable notice of his intention. An action for malpractice cannot be brought after he has recovered in court for his services. He is relieved from responsibility when the patient fails to follow his advice. He is responsible for negligence or ignorance on the part of his assistants, but not for criminal acts on their part. He is not responsible for errors of judgment in uncertain or difficult cases.

Edwin Welles Dwight.

MALT.—(*Maltum*, U. S. P., 1880.) The official directions given in the United States Pharmacopœia for the preparation of this product are as follows:

"Malt, in coarse powder, not finer than No. 12, one hundred (100) parts; water, a sufficient quantity. Upon the powder, contained in a suitable vessel, pour one hundred (100) parts of water and macerate for six hours. Then add four hundred (400) parts of water, heated to about 30° C. (86° F.), and digest for an hour at a temperature not exceeding 55° C. (131° F.). Strain the mixture with strong expression. Finally, by means of a water-bath, or vacuum apparatus, at a temperature not exceeding 55° C. (131° F.), evaporate the strained liquid rapidly to the consistence of thick honey. Keep the product in well-corked vessels in a cool place."

The almost universal employment of malt preparations, especially liquid malt extracts, by physicians and by the laity, warrants a critical study of their value from a therapeutic standpoint. This naturally implies an investigation of the composition of malt, its properties as a food substance from a physiological point of view, and finally, an estimate of its virtues alone, or combined with other medicaments, in the treatment of disease. And, inasmuch as there is a popular demand for these products, some reference should also be made to adulteration, and the addition of foreign substances, principally antiseptics, to prevent fermentation.

Composition.—The manufacture of malt consists essentially of four different processes, viz.: *Steeping*, *couching*, *flooring*, and *kiln-drying*, which result in decreasing the weight of the grain (about twenty per cent.), but are attended with an increase in bulk (three to eight per cent.). The entire manipulation should be considered to be successive steps of the same operation, since malting merely effects the transformation of the substances of the grain, through the influence of heat, moisture, and the amylolytic action of *diastase* (which see). Through the action of diastase—manifested within an hour after grain is put to steep—the insoluble starch of barley is converted into dextrin and glucose—sometimes called grape-sugar. Thus, the outline of Proust (*loc. cit.*) shows that malt contains nineteen per cent. less starch and cellulose than barley, ten per cent. more sugar, eleven per cent. more dextrin, while the amount of gluten is lessened by two per cent. It should be stated in this connection that, while the object of "malting" is to produce the maximum of sugar by the action of diastase, it is not desirable that this action should be entirely exhausted, and therefore, at a certain stage of the operation this process is arrested by kiln-drying; under favorable circumstances—heat and moisture—this fermentation is re-kindled.

Qualitative tests for *diastatic activity* are extremely simple. A quantity of malt is added to hot water, and dissolved by constant stirring; then a small portion of starch is added in like manner, and in the course of a few minutes the iodine test is applied.

The *soluble extract* in a good malt suitable for brewers' use, is, according to Ure, 66.8 per cent.; it contains, in addition, insoluble matter, 26.7, and moisture, 6.5 per cent. To determine the proportion of *insoluble matter*,

a definite quantity is measured by weight and dried by heat from boiling water; the remaining powder is then put in cold water and heated. The soluble extract is then decanted off and the residue dried and weighed and the percentage calculated.

The process of diastatic fermentation is by hydration (Hoppe-Seyler), as will appear later on.

Liquid malt extracts are simply weak solutions of ordinary malt, and usually contain a variable proportion of alcohol, a small percentage of carbonic acid, with more or less solid extract, but for none of them can be claimed any distinct diastatic property. These preparations hold in solution the products of diastatic activity, dextrin and sugar, which renders them "sweet" and palatable, while the alcohol is not in sufficient amount to interfere materially with the proper performance of the digestive functions; indeed, in the case of elderly persons, it may prove a decided benefit. Carbonic acid is also acceptable to the stomach; but the percentage of "*solid extracts*" in these products furnishes no criterion as to their intrinsic value, as will be shown presently.

From an examination and analysis of thirteen different samples of liquid malt extracts, Leffmann (*Medical News*, January 28th, 1893) found that all save one contained alcohol in small proportion—none as high as eight per cent.,—and that the solid extract ranged from 5.1 gm. to 16.06 gm. for each 100 c.c. Moreover, three of the samples contained appreciable amounts of salicylic acid.

ADULTERATION.—The temptation to sophisticate malt arises from the great care required in the process of malting; if the diastatic power be destroyed by excessive heat, the malt possesses no nutritive or digestive value. Again, in sections of the country where malting is extensively carried on, manufacturers may employ "ungerminated" grain, *i.e.*, grain that has been subjected to "heating," and has thus lost its vitality. As a result of wet seasons, therefore, malt may be of a very inferior quality—possessing but slight diastatic power, yet showing a large percentage of insoluble matter.

Most serious objections are urged against the employment of salicylic acid as an antiseptic, since it is harmful if taken in too large quantities or too long continued, and besides, like all other antiseptics, it arrests or suspends diastatic activity. Now, while this is true in general, it may not apply uniformly to malt-takers and beer-drinkers, because we know that even in the absence of diastatic power this class generally present a rotund, florid, sometimes a bloated appearance—due to the deposit of fat from the absorption of sugar—and frequently suffer from rheumatic affections; hence the introduction of salicylic acid free from impurities may possess negative value: (1) by enacting the rôle of an antiseptic in the alimentary canal, (2) by lessening the diastatic activity, thereby preventing the rapid conversion of starch, and (3) by its influence upon the rheumatic diathesis. This leaves, then, for the liquid malt extracts containing salicylic acid, nothing of special value except the converted sugar and a small proportion of alcohol.

INCOMPATIBLES.—The following table (after Hermann Meyer and Brunton) is introduced to show the strength, in watery solution, of the different drugs which arrest the action of diastase, from which it will be observed that while chloroform and creosote, even in saturated solution, have very little or no deleterious effect, corrosive sublimate in a solution so weak as 1 to 50,000 destroys the ferment. Thus salicylic acid in the proportion of one grain to ten ounces (approximately) is sufficient to arrest the action of diastase:

Alcohol, 1 to 3.	Corrosive sublimate, 1 to 50,000.
Benzoate of soda, 1 to 100.	Creosote, no action in sat. sol.
Benzoic acid, 1 to 1,025.	Eucalyptus oil, acted only in excess.
Borax, 1 to 100.	Glycerin, 1 to 2
Bromine, 1 to 5,070.	Iodine, 1 to 4,125.
Carbolic acid, 1 to 30.	Mustard oil, only lessens action in sat. sol.
Chloride of lime, 1 to 6,613.	Salicylic acid 1 to 5,100.
Chlorine, 1 to 7,411.	Sulphurous acid, 1 to 8,600.
Chloroform, slight action in sat. sol.	Thymol, slight action in sat. sol.
Copper sulphate, 1 to 6,500.	

PHYSIOLOGICAL ACTION.—From the preceding remarks it will be apparent that there is comparatively little to add in regard to the physiological action of malt, either from the standpoint of the clinician or from that of the physiologist; and yet that little is of paramount importance. Malt performs a twofold action in that it is a digestive and nutrient, its virtues being augmented by hydration. Digestibility is the prime element in all foodstuffs, but concentration may seriously interfere with absorption; hence the importance of dilution by water, which is the most efficient medium for the transmission of pabulum through the secreting structures of the alimentary tract (endosmosis). Thus, while concentration is an important factor entering into questions relating to the manufacture and transportation of food products, the very opposite is essential to insure rapid absorption and easy assimilation. But the increased consumption of carbohydrates, while it increases the amount of fat, is at the expense of muscular structures which require nitrogenous material for the maintenance of their integrity, and therefore too much dependence must not be placed upon the apparent gain secured by the administration of malt and predigested foods of this character. Indications of their unfavorable effects will be manifested by acidity, hepatic and cardiac derangements, and constipation, along with mental hebetude and other evidences of imperfect metabolism.

Contraindications to the employment of malt preparations in the treatment of children's diseases, more especially those peculiar to summer and autumn, should be noticed, viz.: evidences of fermentation in the stools. When this condition is present, carbohydrates must be omitted and nitrogenous food substituted.

The dangers arising from the small percentage of *alcohol* in the liquid malt extracts have been unduly magnified, as we have ample evidence of its value as a reconstructive. In suitable amounts—*with meals*—alcohol improves the appetite, favors digestion, lessens the elimination of phosphorus, and promotes the excretion of urea, thus enhancing muscular capacity; but we must bear in mind also that alcohol *lessens oxidation*—a conservative process in certain wasting diseases,—although an effect to be avoided in health. Its obtunding influence upon the nervous system is likewise of medicinal importance, and in the administration of malt preparations we should never lose sight of the physiological functions of the organism, our sole object being to restore and maintain its integrity by the exhibition of remedies adapted to its wants.

There is still another important factor to be considered in connection with the physiological functions of malt. For example, a considerable percentage of cod-liver oil can be incorporated with it in such a manner that the compound is tolerably stable while freely miscible with water, and therefore readily assimilable by the digestive apparatus. Now, bearing in mind that malt contains more or less gluten, perhaps a little dextrin, together with some unconverted starch and *insoluble extract*, it is not unreasonable to believe that under normal conditions the contents of the intestine may approach the type of a mucilaginous substance, possessing cohesive properties, and whose viscosity will prove of value in preventing the absorption of poisonous products from the alimentary tract. Physicians readily appreciate the value of starch enemata in irritable conditions of the lower bowel, although but few understand the *modus operandi* by which these benefits are secured. Starch enemata are of service, not merely because they have a quieting effect upon the terminal filaments of sensory nerves in the mucous structures, but rather on account of their adhesive qualities, which enable them to lay hold of poisonous substances in the course of elimination, thus preventing them from coming into contact with the delicate and inflamed tissues. While the old idea has long been accepted as a clinical fact, it was nothing more than a temporary hypothesis or makeshift, and is promptly set aside to make room for the scientific fact upon which it depends.

And just here should be pointed out the marked simi-

larity or analogy between the conditions which obtain in the small intestine when malt is administered and that of the lower bowel when a starch enema is introduced. This explanation not only sheds a new light upon the incidental physiological action of malt, but it puts the entire theory of the therapeutic action of emulsions upon a scientific basis, in keeping with the results of clinical observation. Heretofore the causes which were actually responsible for the wonderful improvement following the exhibition of comparatively small quantities of malt, cod-liver and petroleum oils, as well as other remedies in the form of emulsion, have been scarcely realized, because the physiological functions of the emulsionizing agents were overlooked or but imperfectly understood. Notwithstanding the fact of its being a negative virtue, it is, nevertheless, a factor of material significance.

THERAPY.—The most important therapeutic application of malt consists in its employment for the relief of *intestinal affections* dependent upon imperfect intestinal digestion of starchy foods and subsequent fermentation. In this class of cases the carbohydrates should be restricted, bread only being allowed, and the patient instructed to masticate it thoroughly in order to incorporate with it the *ptyalin* of the saliva, which serves to break up the starch granules before entering the stomach.

Occasionally *amylopsin* may be added with benefit. This method of treatment will be found available in a very large number of cases of intestinal indigestion associated with *chronic disease*, especially *pulmonary affections*, because, as has already been shown, carbohydrates are fat-producers. They do not, however, increase the capacity of the muscular system, and may therefore do harm by lessening oxidation and obstructing elimination. Shortness of breath, cardiac weakness, or hepatic insufficiency with acidity of the stomach and diminished urinary excretion demand their prompt discontinuance and a complete rearrangement of the dietary.

Malt enjoys deserved popularity as an adjuvant in *convalescence* from protracted illness, as an auxiliary and digestive in the case of *nursing women*, and to a limited extent in the treatment of all *debilitated conditions* of the system; but its continuous or indiscriminate use will eventually result disastrously. Like all other remedial agents, its medicinal employment requires the discriminating judgment of the conscientious and intelligent physician.

In the treatment of *summer diseases*, in both adults and children, malt possesses a high degree of utility, but it is adapted only to the cases in which the stools are putrid and foul-smelling. When the stools are sour-smelling, due to starchy fermentation, malt and malted products are of secondary importance, as they have no influence upon the micro-organisms or other poisons associated with the intestinal disorder. Indeed, there is good reason to believe that the popular method of treating this class of affections by the exhibition of "*barley water*" has been productive of greater mortality rates than would have occurred had all treatment been abandoned. Science absolutely condemns the practice, and clinical observation emphatically indorses her teachings. The personal experience of Dr. Benjamin Ward Richardson, published in the *Asclepiad* some years ago, covering the untoward effects of oatmeal and barley water, should be critically studied by every general practitioner.

ADMINISTRATION.—Malt (U. S. P.) may be given in doses of *one or two drachms*, either with meals or two hours later. Liquid malt extract should be given *with meals*—one or two wineglassfuls.

To meet special demands in the case of malnutrition, malt may be combined with a number of reconstructive medicaments, as follows: Malt with quinine, iron, and strychnine; malt with hypophosphites; malt with peptone; malt with cod-liver oil—but not to exceed the proportion of *ten per cent.*

John Aulde.

MALTA FEVER.—(Synonyms: Levant fever, Mediterranean fever, Neapolitan fever, Rock fever of Gibraltar, undulant fever, bilious remittent fever, etc.)

DEFINITION.—A disease of long duration, characterized clinically by fever, profuse perspiration, constipation, frequent relapses, often accompanied or followed by pains of a rheumatic or neuralgic character, sometimes swelling of joints or orchitis; anatomically by enlargement and softening of the spleen, congestion of the various organs, no enlargement or ulceration of Peyer's patches or other intestinal glands, and the constant occurrence, in various tissues, of a species of micro-organism—the micrococcus melitensis.

GEOGRAPHICAL DISTRIBUTION.—It occurs most frequently in the countries bordering on the Mediterranean, but these limits are being gradually extended. It has been recognized in certain parts of India, in one or two parts of the British Islands, and in Porto Rico. Strong has reported (*Philadelphia Medical Journal*, 1900) a case in Manila, Philippine Islands. Brunner (*Wiener klinische Wochenschrift*, 1900) describes a case which occurred in South Dalmatia. It has been found in the islands of the Caribbean Sea, and in Hong-Kong.

ETIOLOGY.—The micro-organism was first discovered by Bruce in Malta in 1887. It is never transmitted directly from person to person. With our present knowledge it is impossible to say how the poison gains extrance into the organism.

SYMPTOMS.—The period of incubation is not definitely known, but it extends probably from a few days to thirty. The onset is gradual, with feelings of malaise, constipation, headache, anorexia, perspiration, etc. This lasts for from one to two weeks, when the long and monotonous period of the fever begins. The patient is dull, apathetic, without delirium, and anæmic. Constipation is obstinate. The alternating febrile and afebrile periods which characterize the disease continue for from two months to two years. The temperature range shows intermitting waves or undulations of fever of a distinctly remittent type. These periods of fever last for from one to three weeks, followed by an apyretic period, or a period of abatement, lasting for from two to ten days. The daily curve may be intermittent or remittent. Profuse sweats attend the decline of the daily range. The spleen is very large. Although the temperature often ranges high, the patient has no delirium nor restlessness. Neuralgias occur in various parts of the body. The different joints of the body may become red, swollen, and tender, but suppuration in them does not occur. Orchitis may be troublesome and anæmia extreme. Vomiting is usually not marked but constipation is obstinate. Some bronchitis is almost always present.

Hughes divides the cases into four types: 1. The malignant type, which lasts for a week or ten days, and in which hyperpyrexia is marked. 2. The undulatory type, in which the fever goes in waves. This is the most frequent variety and the course of the disease is long. 3. The intermittent type, in which there is a daily rise of fever without other marked symptoms. 4. The irregular types.

PROGNOSIS.—The prognosis, so far as life is concerned, is favorable. The mortality is about two per cent.

DIAGNOSIS.—This can be positively made, according to Wright and later authors, by means of the serum agglutination reaction. Thus, in one case, on the tenth day of the disease, the blood serum showed a marked agglutination of the specific micro-organisms, in a dilution of 1 to 60, in the course of twenty minutes. Even higher dilutions than this have produced it. Aldrich states that the reaction first occurs on the fifth day. The serum of such a patient does not have any effect upon the typhoid bacillus nor upon other organisms. By puncture of the spleen with an aspirating needle one can obtain a clear colony of the micrococcus melitensis. Malta fever differs clinically from typhoid fever principally in being of longer duration, in the absence of the characteristic roseola, in constipation being the rule instead of diarrhœa, in the frequent presence of painful articular complications, in the much larger size of the spleen, in the absence of the diazo and Widal reactions, in the absence of the bacillus typhosus from the stools, in the free cerebrum, and

finally in the much smaller rate of mortality. Microscopical examination of the blood will exclude malarial and recurrent fevers. There are usually no symptoms which point to tuberculosis, malignant endocarditis, internal suppuration, or liver abscess. The urine and sputum are negative.

TREATMENT.—This consists principally in prophylaxis. All the sanitary arrangements of the house should be carefully gone over and put in healthy condition. Personal health should also be attended to. There is no specific medicinal treatment known for combating this fever and drugs are not of much avail. Quinine and the salicylates have been extensively used but with no beneficial influence. On the contrary, the effect has been deleterious when pushed as they have been. A careful diet and hydrotherapy are our main reliances.

Clarence Arthur McWilliams.

MALVA and **MALVACEÆ.**—This large family, of some thirty-three genera and nearly a thousand species, has yielded a large number of articles to the Materia Medica, besides *cotton* and *marshmallow*, which are elsewhere described. The most important of these substances are the leaves and flowers of the Hollyhock, *Althæa rosea* (L.) Cav., and of various species of *Malva*. All have been used chiefly as demulcents, for the mucilage with which they abound, the flowers also for their coloring matter, in coloring tinctures and other preparations. Their properties are thus of the simplest possible character and this brief mention is accorded them on historical, rather than on any practical grounds.

Henry H. Rusby.

MANACÁ.—*Mercurio Vegetal.* Preferably the root, but also the stem, of *Brunfelsia Hopeana* Benth. (fam. *Solanaceæ*).

It contains resin, gum, tannin, and probably an alkaloid, in small amount.

Manacá is a well-accredited drug throughout Brazil in the treatment of syphilis, but this repute is apparently due, for the most part, to erroneous diagnosis. It is also credited with antirheumatic properties. Several attempts have been made to develop its use in this country, but with little permanent result. There is, however, a small steady sale for it and its preparations. Certainly, when given in large quantity it has very active properties, being purgative, diaphoretic, and narcotic. Its continued use by those who have had experience with it at least justify a credence in some alterative virtues. The dose is 0.45 to 2 gm. (gr. viij.–to xxx.).

Henry H. Rusby.

MANGANESE.—I. GENERAL MEDICINAL PROPERTIES OF COMPOUNDS OF MANGANESE.—In their medicinal relations the compounds of manganese divide into two distinct groups, the one in which the metal is the basic radical of the compound, the other in which, on the contrary, it is the acid radical. The compounds of the former group, after absorption, probably affect nutrition after the general manner of the heavy metals, tending in small dosage to improve blood quality and quicken general assimilation, and, in large, to derange the nutritive processes, leading to emaciation and nerve-poisoning. Locally, the effects differ with the individual compounds according to their solubility. Therapeutically, the constitutional influence of manganese has been sought as an adjuvant to that of iron, largely upon theoretical grounds, because of the alleged presence of manganese, in small quantity, in association with iron in the composition of hæmoglobin. Doubtless the influence in cachectic states is good so far as it goes, but doubtless also it is, in degree, insignificant as compared with that of iron, with which medicine manganese is, for the present purpose, almost invariably prescribed. Physicians generally have, therefore, failed to see the necessity for combining a salt of manganese with their chalybeates. Locally, the therapeutics of the compounds of manganese are individual to the compounds, and will be detailed below.

The second division of the manganese compounds, where the metal occurs in the acid radical, is represented in medicine by but a single salt, namely, *potassium permanganate*, whose virtues inhere mainly in the property of permanganates to act as oxidizing agents, as will be set forth further on.

II. THE PREPARATIONS OF MANGANESE USED IN MEDICINE.—These are, of manganese as basic radical, *manganese dioxide* and *manganous sulphate*, and of the metal as an acid radical, *potassic permanganate*.

Manganese Dioxide: MnO_2. This compound, commonly known as *black oxide of manganese*, is a native mineral, and of a quality representing at least sixty-six per cent. of the pure oxide, is official in the United States Pharmacopœia under the title *Mangani Dioxidum*, Manganese Dioxide. The mineral differs a good deal in appearance according to the source from which it is derived. It occurs sometimes in metallic-looking lumps, sometimes in fine shining crystals—the form in which it is purest—but yet is most commonly found in the condition of powder. This powder is heavy, grayish-black in color, more or less gritty and without odor or taste. It is insoluble in either water or alcohol. At a red heat it gives off oxygen gas. Manganese dioxide, as usual with the insoluble metallic oxides, is locally bland, and in the stomach tends to allay irritability of that organ. Continuously given, it is capable of absorption, with constitutional effects of manganese. Medicinally, the oxide has been applied in skin disease, in ointment (twenty-five per cent. strength), and has been given internally in gastric irritation; but its grittiness makes it an unpleasant medicine to take in form of powder. The average dose is 0.65 gm. (gr. x.) three times a day. Much more important than any medicinal application is the use of the dioxide in the laboratory, in the preparation of oxygen gas, chlorine, and also of iodine, when the latter is obtained from kelp.

Manganous Sulphate: $MnSO_4.4H_2O$. The salt is official in the United States Pharmacopœia as *Mangani Sulphas*, Manganese Sulphate. This salt occurs in colorless or pale rose-colored transparent prismatic crystals, which may contain variable proportions of water of crystallization according to the temperature of the mother solution. The Pharmacopœia recognizes crystals containing four molecules of water of crystallization. The salt dissolves in less than one part of water, cold or boiling, but is insoluble in alcohol. It effloresces slightly in dry air and should be kept in well-stoppered bottles. Manganous sulphate is sharply irritant and specifically purgative, and has the reputation of being also specifically cholagogue. This latter reputation is based largely on an old assertion of C. G. Gmelin, that in experimenting with animals with the salt, a considerable outpouring of bile was determined. Rutherford's later and careful experiments, however, failed to produce a like effect. In large dose, manganous sulphate is an irritant poison. Medicinally, the purgative and alleged cholagogue action have been utilized by some prescribers, but since the salt is harsh in action and disagreeable to the taste, its use as a medicine has not found much favor. From 0.65 to 1.30 gm. (gr. x.–xx.) is a full purgative dose, not to be exceeded.

Potassium Permanganate: $K_2Mn_2O_8$. The salt is official in the United States Pharmacopœia as *Potassii Permanganas*, Potassium Permanganate. It occurs in deep purple-violet, or nearly black, needle-shaped, rhombic prisms, of a metallic lustre, without odor, but with a sweet, afterward disagreeable, astringent taste. It is permanent in the air; dissolves in 15 parts of cold and in 3 parts of boiling water, and is decomposed by alcohol. Weak solutions of potassium permanganate are of a delicate rose color, which should be free from tinge of green. Strong solutions are of deep purple, and have the troublesome property of staining, not only fabrics, but the skin; and even porcelain-ware will be colored a rusty purple under sufficient contact. Potassium permanganate in strong application is irritant and even caustic, but its medicinal application hinges mainly on its peculiarity

of being a powerful oxidizing agent, because of the ready disengagement, in presence of oxidizable matters, of a portion of the oxygen of the permanganic acid. By virtue of this property the salt promptly destroys fetor and fetid materials as such, and is one of the most efficient agents known for such purpose. Its disadvantages are its comparative costliness and proneness to stain. Because of its oxidizing tendency, it is necessary to keep the compound in well-stoppered bottles, and to avoid admixture with it of organic or other easily oxidizable matters. Trituration of the crystals with inflammable substances may even determine explosions. Potassium permanganate is a valuable detergent for foul surfaces, as of sloughing wounds, ulcerated cancers, etc., and is applied in aqueous solution ranging from one-fifth per cent. to four per cent. in strength. The weaker solutions are used where a mere deodorizing is sought, the stronger where a vital action also is desired, as in the case of gangrenous ulceration. To sweeten foul drinking-water a solution of the salt may be added to the water gradually, so long as the color is discharged on stirring, a circumstance that will continue as long as any organic matter remains unoxidized. So soon as the coloration persists, even in faintest shade, further addition is to be discontinued. The small percentage of permanganate then remaining in excess will neither be perceived in taste, nor will it do any harm. Solution of the permanganate is an excellent disinfectant by which to cleanse and sweeten water-closet traps, etc. For this purpose the impure salt, which is much cheaper than the pure, may be used. A drachm or so of the impure crystals may be dropped into the water of a water-closet trap and allowed to remain for a few minutes, when the trap should be flushed. Care should be taken not to leave a strong solution in contact with marble or porcelain for any length of time, lest staining occur. Potassium permanganate has been used internally in zymotic diseases, presumably with the idea of chemically assaulting the virulent essence of the same; but inasmuch as any allowable dose of the salt must inevitably exhaust its oxidizing capacity while *en route* through the organic matters of the alimentary canal to the vascular system, the practice has not even a sound theoretical basis to justify it. The doses given are from 0.015 to 0.06 gm. (gr. ¼ to i.) three times a day, taken in solution in distilled water. More recently, Ringer and Murrell have announced success with the internal use of potassium permanganate as an emmenagogue, giving the medicine in doses of a grain, increased to two grains, three or four times a day. Similar success has since been reported by a number of other practitioners, and success also with certain cases of menorrhagia and metrorrhagia, as well as of amenorrhœa (F. H. Martin). The medicine is best borne in pill form, but even when so taken occasionally produces a good deal of gastric distress. Because of the powerful oxidizing property of the permanganate, care must be taken in the selection of excipients for making the medicine into pills. The following has been recommended as an excipient: "Vaseline, two parts; paraffin-wax, one part; melt, stir till cold, and add kaolin, three parts; mix well." The pills, after being made, are to be dusted with kaolin.

The permanganate decomposes alkaloids, by oxidation, and has been recommended, accordingly, for internal giving in cases of alkaloidal poisoning, in order to destroy such of the poison as may still be present in the stomach. Similarly it has been recommended to inject a solution of the permanganate into the tissues of a part bitten by a venomous snake, if the application can be made soon after the infliction of the bite.

Edward Curtis.

MANGANESE SALTS, TOXICOLOGY OF.—The salts of manganese are in general feeble poisons, though some of them have decided toxic action. After subcutaneous injection, excretion occurs chiefly by the kidneys and mucous membranes of the stomach and intestines. Manganese compounds have been found in traces in the hair, urinary calculi, and gall stones.

Manganese oxid (MnO), in doses of 6 to 8 mgm. per kilogram, administered to dogs proved fatal in two days; 13 to 24 mgm. per kilogram caused death in twenty-four hours.

Manganese dioxid (MnO_2), used in paints, has caused paralysis of the arms and legs and of the organs of speech that either disappeared after several years or not at all.

Manganese sulfate caused vomiting in dogs, and paralysis in rabbits, and after being injected into the veins, it produced vomiting, loss of appetite, and tetanic cramps. Four grams caused death in rabbits.

Manganese-sodium basic citrate caused symptoms similar to those due to the sulfate, with paralysis of the vaso-motor centres, icterus, loss of motor power and sensibility, and coma.

Manganese carbonate, from experiments on rabbits, appears to be non-poisonous.

Potassium permanganate, in a quantity of from 15 to 20 gm., caused death in twenty-four hours in a case of suicide. After the internal medicinal use there have been observed pain in the mediastinum extending to the stomach, vomiting, and abortion. The application of a four-tenths-per-cent. solution to the mucous membranes caused inflammation, hemorrhage, and suppuration. In cases of poisoning by manganese salts, evacuation of the stomach, intestines, and kidneys by emetics, purgatives, and diuretics, and the use of heart stimulants when indicated, offer the best treatment.

To recover manganese from the tissues, these are treated as in the method of Fresenius and Babo, and after the removal of any metals whose sulfids are insoluble in acid solutions the filtrate is rendered alkaline with ammonium hydroxid and the manganese precipitated with ammonium sulfid as flesh-colored manganese sulfid. Re-solution and reprecipitation will doubtless be necessary to remove the last traces of organic matter.

Curtis C. Howard.

MANHATTAN ARTESIAN WELLS.—Riley County, Kansas.

Post-Office.—Manhattan. Hotel.

These wells are located in a hilly country, eleven miles southeast of the town of Manhattan, and at an elevation of about 800 feet above the sea level. The wells are two in number, and discharge about 24,000 gallons of water daily. This is of the sulphated-saline variety, and has a uniform temperature of 55° F., summer and winter. The following analyses were made by Professor Failyer of the Kansas Agricultural College:

Well No. 1 (Mineral Water).

One United States Gallon Contains:

Solids.	Grains.
Calcium oxide (as bicarbonate)	5.27
Calcium oxide (as sulphate and chloride)	33.36
Magnesium oxide (as sulphate)	5.65
Iron oxide (bicarbonate)	.18
Sodium (as chloride)	.51
Potassium	Trace
Sulphuric acid (anhydrous)	61.36
Chlorine	1.46
Bromine	Trace
Silica	10.09
Lithium	Trace
Total	117.88

Well No. 2.

One United States Gallon Contains:

Solids.	Grains.
Calcium oxide (as bicarbonate)	6.07
Calcium oxide (as sulphate)	14.69
Magnesium (as sulphate)	6.58
Iron (as bicarbonate)	.24
Sodium (as chloride)	.86
Potassium	Trace
Sulphuric acid (anhydrous)	33.11
Chloride	1.79
Silica*	10.18
Total	73.52

* According to United States Geological Reports Well No. 2 contains 1.19 grains of Silica per United States gallon.

The waters have been in use since 1884, and have been found beneficial in rheumatism, malaria, renal disorders, constipation, general debility, and diabetes. The waters themselves, as well as the salt remaining after evaporation, are used commercially. *James K. Crook.*

MANILA AND THE PHILIPPINES.—The Philippine archipelago is situated between 4° 4′ and 20° 3′ north latitude and 116° 4′ and 126° 4′ east longitude, Greenwich. On the east and northeast is the Pacific Ocean and on the west and northwest, the China Sea. In general shape the archipelago may be likened to an inverted Y, having its base, the island of Luzon, to the north, its major branch, the islands of Samar, Panay, Negros, and Mindanao, diverging to the southeastward, and its minor branch, the narrow island of Palawan, diverging to the southwestward. Between these two branches is the Sulu sea, partly enclosed to the southward by the northeast shore of the large island of Borneo and a chain of small islands stretching from Borneo to the southwest extremity of Mindanao, the Sulu archipelago. Farther south of the archipelago, about 300 miles, are the Celebes, and a little less distant on its north is the island of Formosa. The nearest point to the China coast is 390 miles from the most northern extremity of Luzon. According to the report of the United States Philippine Commission (Washington, 1901), the number of the islands comprised in the cession to the United States is believed to exceed 1,400; other authorities have variously estimated the number from 600 to 1,200 or more. By far the most of the members of the archipelago are small, and very many are insignificant both in size and economic importance. The total estimated area is, in round numbers, 130,000 square miles. The principal islands of the Philippine group are:—

	Sq. miles.		Sq. miles.
Luzon	40,000	Leyte	3,000
Mindanao	47,000	Negros	3,200
Samar	5,300	Cebu	1,600
Panay	4,600	Masbate	1,300
Palawan	4,200	Bohol	900
Mindoro	4,050		

The Sulu Islands, or archipelago, before referred to, are estimated as containing 1,500 square miles.

History.—The Philippines were discovered by Magellan, March 12th, 1521, in his memorable voyage of circumnavigation, and on April 27th of the same year he was ingloriously killed in a skirmish with the natives on the little island of Mactan, off the east coast of Cebu. Magellan took possession of the archipelago in the name of the king of Spain. In 1565 Legazpi founded in the island of Cebu the first Spanish settlement, and in 1571 fixed the capital of the islands at Manila. The archipelago was for some time known under several appellations. Its present name (*Islas Filipinas*) was suggested by Villalobos in 1543, but it first appeared in written form in 1567 in a letter of Legazpi's. The archipelago appears from the first to have been virtually turned over by Spain to the different orders of the Roman Catholic missionaries, and its conquest and civilization from thence on were practically accomplished by them. The political history of the islands, so far as relates to their foreign relations, with the exception of the capture of Manila by the English in 1762, and its subsequent restoration in 1764, is uneventful until the year 1898. The United States having declared war against Spain, April 24th, 1898, Admiral (then Commodore) Dewey, commanding the United States naval forces in Asiatic waters, entered Manila Bay, May 1st, 1898, and in the most signal engagement in naval annals completely destroyed the Spanish fleet gathered for the defence of the Philippines. The city of Manila was then closely invested by the United States naval vessels on water and by the insurgent Filipino forces on land. Upon the arrival of land troops from America, a combined land and water attack, more a demonstration to satisfy Spanish honor, was made and Manila surrendered to the United States forces August 13th, 1898. By the treaty of Paris, December 18th, 1898, Spain ceded the Philippines to the United States. In 1899 the Filipinos, who had been in a chronic state of insurrection against Spain since 1896, becoming dissatisfied with the American policy, commenced overt hostilities February 4th, 1899. Since then engagements of more or less seriousness between the Americans and the insurgents have taken place. The latter, after their first few unsuccessful engagements in open battle, abandoned any attempt at organized warfare and resorted to that of the guerilla and bushwhacker. This kind of warfare has lingered on, much to the distraction of business in the islands, but fortunately at the present time (July, 1902) the prospects of the pacification of the archipelago appear nearing consummation. The domestic history of the islands previous to their American occupation appears to have been but a repetition of the misgovernment and official corruption so characteristic of all of Spain's colonial history.

Population.—The estimated population of the Philippines is 8,000,000 inhabitants. Of this number, excluding soldiers and sailors, about 25,000 are either Americans or Europeans, and about 100,000 are Chinese, and the remainder natives. The native population is represented by three distinct races, and in varying degrees of racial purity—namely, Negritos, Indonesian, and Malayan. The Negrito, the lowest race in the ethnologic scale, is now found pure only in the forests of the high mountains of Luzon, Panay, Negros, and Mindanao. From present indications the race will soon become extinct. The Negrito is small in stature, from 4.2 to 5.2 feet in height, with skin intensely black, hair short, crisp, curly and of a sooty blackness, lips thick, nose of medium size, flattened and broad at its base. Making no preparation for future wants, content to sleep where night overtakes him, armed only with a bow and arrows, the Negrito is the typical nomad and savage. The pure Indonesian is found only, as far as known, in Mindanao. The type is described by Dr. Montano as of considerable height, muscular development, high forehead, aquiline nose, wavy hair, and in the male abundant beard. The color of the skin is quite light, the individual clever and intelligent. The Malayan is difficult to characterize, because of more or less intermixture that has taken place in the race with that of the Negrito, Chinese, and Indonesian. On the whole, the Malayan is not so tall as the Indonesian, his skin is darker and his nose straighter. He has a medium to large-sized mouth, thick lips, black, straight, thick, and coarse hair, and in the male little or no beard. His intelligence is intermediate between perhaps the Negrito and the Chinese. The European mestizo is intellectually and politically the most important member of the native population, and is found everywhere throughout the archipelago, but is most numerous in the important cities and towns.

With the exception of tribes in the interior of the larger islands most of the Filipinos are civilized and in a certain sense Christianized. Human sacrifices are stated to be practised by at least two tribes in central Mindanao, and head hunting is engaged in by some of the north Luzon tribes. The primary educational advantages offered to the Filipinos under Spanish domination were limited in the extreme. The number of teachers to population averaged something like one teacher to 3,500 inhabitants. A few schools, however, of good standing existed in Manila. For an education higher than that obtainable in the primary school the facilities appear to have been a little better. The Royal and Pontifical University of Santo Tomes conferred degrees in theology, philosophy, jurisprudence, and physics and chemistry. The College of San José also gave philosophical instruction, and from 1875 it conferred degrees in both medicine and pharmacy. Other schools, such as the School of Arts and Trades, of Agriculture, of Painting and Sculpture, and the Nautical School, and several theological schools may be mentioned. The standard of these schools, however, was not that of institutions of the same apparent rank in either Europe or America.

The principal export products of the islands are hemp, sugar, copra, and tobacco. The means of transportation are limited and poor. The only railroad runs from Manila to Dagupan, a distance of 120 miles. Other railroads are much needed and will do much toward developing the latent resources of the islands. Ordinary roads can hardly be said to exist—they are but little more than trails and are impassable for traffic during wet weather. Most of the important towns and islands are in telegraphic communication, and Manila is connected by cable with Hong-Kong. Labor for any enterprise is difficult to obtain. The Filipinos are not steady workers; the most reliable laborers obtainable are the Chinese, and further immigration of these is now excluded.

Manila, the capital, as well as the chief port and largest city of the Philippines, is situated on the east shore of Manila Bay, on the west coast of the island of Luzon. The city was established by Legazpi as the capital of the archipelago in 1571. The general elevation of the land is low, being but a few feet above tide water. The immediately adjacent country is more or less flat. The Pasig River, flowing from east to west, divides the city into two parts. The Bay of Manila is too large and exposed to be a safe harbor at present. It is also shallow near the city, so that vessels of great draught cannot come to anchor nearer than from two to two and one-half miles from shore and must discharge their cargoes by lightering. However, improvements are progressing, a breakwater intended to protect shipping in all weather is under way and dredging operations are making the nearer approach of large vessels possible. The population of Manila, according to the census taken by the United States military authorities in 1901, was 244,732, exclusive of the military and naval forces. This number was divided as follows: Americans 8,461, Filipinos 101,361, Chinese 51,567, Spaniards 2,382, and other nationalities 961. Under Spanish domination the city did not present much to attract visitors. The houses, with few exceptions, were described as inferior in size and appearance, the hotel accommodations miserable, the streets narrow and unpaved, or paved only with rough cobblestones, and deep in mud for three-quarters of the year and in dust for the other quarter. In contrast, however, the shops were said to be good, equal to those of Hong-Kong or Calcutta, and the prices very reasonable. The sanitary condition of the city, with the notable exception of a fairly good water supply, was execrable,—in fact, no system at all. Much has been done since the American occupation and much yet remains to be done to make Manila a sanitary city.

Geology.—From a geological basis of reckoning, the archipelago is of modern formation. Evidences of existing elevation and subsidence are to be seen in many places. Prof. Dean C. Worcester states that it is not unusual to have a native assure one that he now fishes where his grandfather used to live, or lives where his grandfather used to fish. Volcanoes, active and extinct, are to be found in many localities and earthquakes are of frequent occurrence, and sometimes very destructive. In 1863 the most destructive one of recent times occurred, when it was estimated that 400 people were killed and very many more injured, and 46 public buildings and 1,100 private houses were damaged or completely wrecked. All of the islands are in general mountainous, though as far as known no elevations much in excess of 9,000 feet have been discovered. Most of the ranges apparently do not exceed 1,500 to 2,000 feet in general elevation. The usual direction of the mountains is north and south. The archipelago is well watered and many of the streams are of good size. Although the Philippines have been known to Europeans more than three centuries, very little exact knowledge is possessed with regard to either their geology or their flora and fauna. Little or nothing has been done to develop the mineral wealth of the islands. Coal of good quality has but recently been discovered in Cebu. Excellent lignite has been long known to exist in Luzon, Cebu, Masbate, and Mindanao. Copper ore and galena occur in Luzon and some other parts of the archipelago. Gold has been crudely mined in small quantities by the natives for centuries. Modern methods of extraction will doubtless greatly increase the output of this metal. Excellent iron ore is found in Luzon, but so far it has not been developed. Marble and gypsum are found in many of the islands. Free-flowing petroleum has been discovered within a few years past in Cebu, and sulphur exists almost everywhere in inexhaustible quantities.

Flora.—A rich soil and favorable climatic conditions give a flora of magnificent variety and abundance. The agricultural possibilities of the islands have not been developed by the primitive methods of cultivation hitherto in vogue. So far, attention has been mainly devoted to the production of hemp, sugar, and tobacco. Rice is grown fairly successfully and forms a staple food of the natives. Coffee grows readily and its quality is excellent. Recently, however, the coffee plants have been virtually ruined by the attacks of a wood-borer. Until some means of extirpating this pest are found the industry will have to be abandoned. Cotton of an inferior quality grows wild. Long-staple cotton was at one time introduced, but it was abandoned because the authorities preferred the natives to grow tobacco, then a government monopoly. Cacao, castor oil bean, cocoanuts, gutta-percha, potatoes, maize, rattan, and many varieties of useful palms are grown in greater or less quantities. In fact, it appears that there is no limit to the variety of agricultural products, tropical, semi-tropical, and even many of the varieties of colder climates, that may not be profitably cultivated under intelligent supervision.

The forests abound in many valuable woods. More than two hundred kinds have been considered worthy of industrial use. Fifty or more species of hard woods are known, some four of which sink in water. Many of these woods, owing to their hardness, take beautiful polishes and are, therefore, excellently adapted for cabinet work. Others possess qualities that will suit them for general industrial use.

Fauna.—The mammalian fauna of the Philippines is scant in indigenous varieties compared with other islands of the great Australasian group. There are no carnivorous animals of any considerable size. A small wildcat, two civet cats, and the binturong, a related species, are the most conspicuous. One species of monkey, twenty varieties of bats, a few squirrels, a species of porcupine, and several varieties of rats may also be mentioned. Several species of deer exist. The agricultural animals are the water buffalo, or native carabao, the hog, the goat, and a small pony. Cattle of an inferior variety are also found and are extensively raised for beef. The water buffalo is the native beast of all work. The ponies are excellent for travel, but are too light for heavy loads. They are supposed to be descendants of an early Spanish stock. Birds are numerous and in great variety. Jungle fowl, hornbills, and fruit pigeons are in abundance and are hunted for and much relished as food. Snipe are plentiful in rice fields and a species of swift, whose nest is prized by the Chinese for food, is found on some of the precipitous island coasts. Alligators, or crocodiles, are common and frequently attain large size. The natives show very little fear of them, although they state that when the crocodile has once tasted human flesh it will then have no other. Snakes are numerous and venomous species are found. Cobras exist in Samar and Mindanao, and pythons, though of small size, are found generally throughout the archipelago. The python in fact is maintained by the natives about their dwellings, being much prized for its rat-catching proclivities. Fish are plentiful and in great variety. The marine fish form one of the chief sources of food supply, but the fresh-water varieties are not so important in this respect. Shellfish are likewise numerous. Extensive beds of pearl oysters are fished near the Sulu Islands. From a variety of oyster are obtained the "concha," thin squares of shell used in dwellings in place of the common window glass.

Locusts, termites, and mosquitos are much in evidence. The first two are very destructive and the third most

annoying. There are also other insect pests, two species of which cause much damage to the rice crop, and another has, as before mentioned, practically destroyed the coffee industry. Bees of three varieties are found. Butterflies, beetles, spiders, and many other forms of insect life are seen in great profusion.

Climate.—The climate of the Philippine Islands is tropical, that is, it is characterized by high and steady temperature and an abundant rainfall. Statistically it is known mainly from the excellent series of meteorological observations made by the Jesuit fathers at their Observatory of Manila. Through the instrumentality of the same institution observations have been made in or collected from other localities in the archipelago; but, unfortunately, in most instances these observations are for short periods, or are so much broken that their value as climatic data is seriously impaired. With the exception of Manila, temperature observations of sufficient length and continuity are available for but two places: Aparri, in north Luzon, and La Carlota, in the island of Negros. The mean temperatures of these two places are shown in Table I.

TABLE I.—MEAN TEMPERATURES (FAHR.) OF APARRI, N. LUZON, AND LA CARLOTA, NEGROS.

	Jan.	Feb.	March.	April.	May.	June.	July.	Aug.	Sept.	Oct.	Nov.	Dec.	Annual.
Aparri (ten years' record)	74°	75°	77°	80°	82°	83°	82°	82°	81°	80°	77°	74°	79°
La Carlota (eight years' record)	78	79	80	82	82	81	79	79	79	80	79	79	80

The climate of Manila and vicinity is shown in detail in Table II.:

TABLE II.—CLIMATOLOGICAL DATA FOR MANILA.

	Jan.	Feb.	March.	April.	May.	June.	July.	Aug.	Sept.	Oct.	Nov.	Dec.	Year.
Temperature (F.°)—													
Mean monthly	77	78	81	83	84	82	81	81	81	80	79	77	80
" of warmest	79	81	82	85	87	85	82	82	82	82	81	80	82
" " coolest	74	76	79	81	82	81	79	80	79	79	77	75	79
Highest recorded	91	96	96	99	100	98	95	94	94	95	94	92	100
Lowest "	60	61	65	66	71	70	70	69	71	69	63	60	60
Mean maximum	86	87	90	92	92	90	87	87	87	88	86	85	
" minimum	69	69	72	74	76	76	75	75	75	74	73	71	
" daily range	17	18	18	18	16	14	12	12	12	14	13	14	
Greatest "	22	27	27	30	24	22	20	20	20	20	22	25	
Least "	4	5	4	8	4	3	3	3	2	3	3	2	
Humidity—													
Mean relative, per cent	77	73	71	70	75	80	84	84	85	82	80	80	78
" absolute, grains per cubic feet	7.75	7.60	7.90	8.42	9.27	9.39	9.33	9.53	9.33	9.24	8.59	8.06	8.75
Wind movement in miles—													
Mean daily	98	115	132	145	144	138	182	165	192	111	94	93	134
Prevailing wind direction	N. E.	E.	E.	S. E.	S. E.	S. E.	S. W.	S. W.	S. W.	N. E.	N. E.	N. E.	
Cloudiness, per cent	45	37	35	32	47	65	74	68	72	58	54	53	53
Days with rain, number of	4.3	2.2	3.4	3.5	9.2	15.4	22.1	19.8	20.7	14.4	11.3	8.4	135
*Rainfall in inches—													
Mean monthly	1.15	.47	.65	1.11	4.30	9.68	14.70	13.88	15.01	7.47	4.92	2.09	75.43
Greatest "	7.59	1.97	3.94	5.37	10.11	25.81	29.71	43.20	61.43	23.65	15.27	13.67	120.98
Least "	.02	.00	.00	.00	.00	.98	5.28	5.15	2.00	.90	1.17	.01	35.65

*Rainfall record for thirty-two years, 1865–96. Other data for seventeen years, 1880–96, with exception of mean maximum and minimum daily ranges, which are for fourteen years.

Temperature.—The average temperature of the year at Manila is 80° F. In describing the climate of Manila the year may be divided into a hot season, an intermediate season, and a cool season. April, May, and June constitute the hot season, with an average temperature for the three months of 83°; July, August, and September, the intermediate season, with an average temperature of 81°; and October to March, inclusive, the cool season, with an average temperature of 79°. May is the hottest month of the year, having an average temperature of 84°, and December and January are the coolest months, with average temperatures of 77°. The highest thermometer reading so far recorded is 100°. The lowest reading ever recorded is 60°. For comparison with other tropical and subtropical places, see tables in articles *Cuba* and *Hawaii*.

Humidity.—The average relative humidity is 78 per cent. The average absolute humidity is 8.8 grains per cubic foot. The humidity is greatest during the months of July, August, and September when its average is 84 per cent., and least during March and April when its average is 70 per cent.

Rainfall.—The average rainfall, from a record of thirty-two years, is 75.43 inches. The year is usually divided into a rainy season and a dry season, although the Spaniards characterized the seasons epigrammatically as "*seis meses de polvo, seis meses de lodo, seis meses de todo*" (six months of dust, six months of mud, and six months of everything). The wet season begins with June and extends to October, inclusive, during which 80 per cent. of the total rainfall occurs. The dry season takes up the rest of the year during which but 20 per cent. of the rainfall occurs. The month of September has the largest average rainfall, 15.01 inches, and February the smallest average fall, 0.47 inch. The heaviest rainfall ever recorded in any one month is 63.43 inches in the month of September. It is not unusual for the months of February, March, April, and May to pass with no rainfall whatever. A consideration of the record of thirty-two years reveals the fact that there are many departures from the average rainfall, and in some instances the departures are remarkable. For example, in one year as much as 120.98 inches fell and in another year as little as 35.65 inches. Still more remarkable, however, are the departures from the averages of individual months. In the case of September, before referred to as the month of greatest rainfall, as little as but two inches has fallen.

The rainfall varies much in other places in the archipelago. From an inspection of Table III. it will be observed that the rainy season is not synchronous in all

TABLE III.—RAINFALL STATISTICS AT SEVERAL STATIONS IN THE PHILIPPINES.

Stations.	Jan.	Feb.	Mar.	April.	May.	June.	July.	Aug.	Sept.	Oct.	Nov.	Dec.
Vigan (ten years' record)	0.0	0.0	0.17	0.14	3.50	8.55	21.09	11.38	19.14	6.94	2.56	0.01
Punta Santiago (twelve years' record)	.26	.01	.22	.18	3.90	7.36	14.48	9.45	12.68	4.76	4.01	2.25
Albay (six years' record)	9.21	6.61	9.02	6.11	7.40	8.18	10.47	9.53	11.81	8.35	11.85	17.99
Aparri (nine years' record)	9.09	3.89	1.88	1.07	2.63	2.29	5.08	6.85	9.53	11.25	9.48	10.39
San Isidro (ten years' record)	.62	.26	.78	.92	8.27	7.59	13.36	11.14	14.22	7.01	4.02	2.03
Tayabas (seven years' record)	4.88	1.92	2.37	.94	3.96	3.49	3.80	2.91	4.59	9.41	11.15	7.70
Sulu (five years' record)	4.06	1.83	1.74	3.29	9.59	5.68	5.74	4.63	5.89	6.46	5.02	6.30
Cebu (six years' record)	3.60	2.05	2.52	.83	4.03	7.53	6.33	6.53	6.50	6.67	4.58	6.77

parts of the archipelago. Indeed, it is practicable by moving from place to place to have rainy or fair weather almost as one choses. In Table III. the stations of Vigan and Punta Santiago are on the western coast of Luzon, Albay on its southeastern extremity, and Aparri on its northern coast. San Isidro and Tayabas are in the interior of Luzon.

Storms.—Thunder storms are of frequent, almost daily, occurrence during the wet season. The electrical display and the rainfall of these storms are much more intense than in the storms of temperate latitudes. However, but little damage results. The most destructive and most dreaded storm of the eastern waters is the typhoon, a cyclonic storm similar in respect to origin, course, and season, and destructiveness to all things in its path, to the West India hurricanes of the Atlantic. The season of maximum typhoon prevalence is from June to October.

Health.—One of the most interesting questions pertains to the health of Europeans and Americans in the archipelago. Unfortunately, no satisfactory answer can be given at present. Spanish sanitary arrangements in the tropics have been notoriously bad, and much of the ill-health prevalent in the Philippines must be attributed to the absolute neglect of the most elementary principles of sanitation. With due attention to the ordinary laws of hygiene, it appears reasonable to expect considerable improvement in the health of both the native and the foreign population. The prevalent infectious diseases are typhoid and malarial fevers, dengue, beri-beri (confined almost exclusively to natives), and smallpox. Intestinal diseases are common and dysentery is especially prevalent, more so during the wet season than during the dry. Notwithstanding the high atmospheric temperature and great degree of humidity, heat stroke is infrequent. Col. Charles R. Greenleaf, U. S. A., chief surgeon, Division of the Philippines, states "that heat stroke so much feared in the tropics is practically unknown here, men drop out in the march overcome by the heat, but fatal stroke and lasting heat exhaustion are very rare." Table IV., arranged from the report of the Surgeon-General, U. S. A., 1901, shows the chief causes of sickness among the soldiers, which may be considered as most likely to be affected by the prevalent climatic and the existing sanitary conditions, and which may be taken as a fair indication of the diseases most common among the native and the foreign populations. The general consensus of expert opinion is that Americans in the islands are prone too much to over-eating and are too indifferent to accommodating themselves to the unusual climatic conditions. The consideration of the subject of clothing suitable for the tropics cannot be taken up here, but it is a matter of much importance to persons contemplating sojourns in equatorial climates. (See article on *Military Hygiene*, in the present volume.) Persons having experience in the islands appear to be united in advising the wearing of light flannels next to the body. Much stress is laid on the importance of protecting the abdomen at night by the use of a light binder. Another point upon which it is imperative to insist is the use of pure water, that is, water that has been made pure by adequate filtration or by boiling. Strict attention to the drinking-water is perhaps the keynote to the situation.

W. F. R. Phillips.

TABLE IV.—RATIO OF SICKNESS PER THOUSAND OF MEAN STRENGTH OF REGULAR AND VOLUNTEER ARMIES IN THE PHILIPPINES, 1900. (MEAN STRENGTH, 66,882.)

Cause.	Ratio of sick.	Ratio of deaths.	Cause.	Ratio of sick.	Ratio of deaths.
Smallpox	3.68	1.69	Diarrheal diseases, other	476.26	1.24
Dengue	49.03	.00	Enteritis	20.66	.40
Typhoid	10.71	2.11	Bronchitis	39.29	.00
Malaria, intermittent	717.83	.00	Pneumonia	2.35	.49
" remittent	153.56	.36	Pleurisy	4.11	.07
" pernicious	2.84	1.23	Consumption	4.89	1.18
Gastritis	45.78	.04	Heat stroke	2.05	.09
Dysentery, acute	83.62	3.07	Measles	4.69	.09
" chronic	44.83	4.77			

MANITOU SPRINGS.*—El Paso County, Colorado.

POST-OFFICE.—Manitou Springs. Hotels: Barker, Cliff House, Manitou House, mansions and numerous boarding-houses.

ACCESS.—Viâ Denver and Rio Grande Railroad and Colorado Midland Railroad.

Manitou is situated six miles west of Colorado Springs, immediately at the foot of Pike's Peak. Here are located the celebrated effervescent soda and iron springs which in early days gave the name of springs to the town of Colorado Springs. An electric railroad, with cars at frequent intervals, unites the two places. The town of Manitou Springs contains a permanent population of more than 2,000 souls, which number is augmented during the summer months by about 125,000 visitors from all parts of the United States and from foreign countries. Dame Nature was in a fanciful mood when she fashioned the topography of this wild and rugged region. Few similar areas of the earth's surface present a greater number and variety of weird, grotesque, and romantic features than are to be found in the vicinity of Manitou Springs. The scope of this work allows us to enumerate only a few of the more prominent points of interest within a few miles of the place. Iron Springs and hotel, one mile; Rainbow Falls and Grand Caverns, one mile and a quarter; Crystal Park, three miles; Garden of the Gods, three miles; Glen Eyrie, five miles; Monument Park, by rail seven and one-half miles, North Cheyenne Park, eight and one-half miles; South Cheyenne Can-

* So called by the Indians ("Manitou," the Great Spirit), to whom the springs were known for many generations.

yon, nine miles; Summit of Pike's Peak (viâ cogwheel railroad), twelve miles. In addition to these well-known localities there are scores of canyons, caves, waterfalls, and charming nooks which the sojourner may seek out for himself. The railroad journey to the top of Pike's Peak is one never to be forgotten. The view from the immense height of 14,147 feet is almost appalling in its scope and grandeur. A post-office for the benefit of tourists is maintained at the apex of the Peak by the national Government during the summer season. It has been well described as the loftiest post-office in the United States. The meteorological conditions at Manitou and Colorado Springs are very favorable to invalids, the climate being dry and the temperature even and not subject to sudden changes. The winter months are mild and pleasant—so mild, indeed, that excursions are almost daily made to the neighboring canyons and glens, where outdoor picnics are held with as much safety to health as in the summer.*

Within the town limits are nine cold springs, which are divided into two groups: (1) the Soda Springs which resemble in taste and properties the well-known Apollinaris water; and (2) the Iron Springs. These springs are controlled by the Manitou Mineral Water Company, and, in addition to the immense local consumption by visitors, the waters are bottled and sold to dealers throughout the United States. The Manitou ginger-ale and Manitou soda-water also have an extensive sale, and an inspection of the immense bottling establishment of the company is one of the features of a visit to the resort. The waters of two principal springs, as analyzed by Prof. Elwyn Waller, Ph.D., analytical chemist, New York City, were found to contain:

MANITOU SPRINGS.

ONE UNITED STATES GALLON CONTAINS:

Solids.	Manitou. Grains.	Navajo. Grains.
Sodium chloride	23.94	23.79
Potassium sulphate	10.68	15.35
Sodium sulphate	11.14	10.93
Sodium carbonate	40.66	42.60
Lithium carbonate	.71	.61
Calcium carbonate	69.08	69.33
Magnesium carbonate	16.68	16.04
Iron oxide	.02	.02
Alumina	.07	.10
Silica	2.49	2.46
Total	175.47	182.23

Both contain free carbonic-acid gas.

The waters of these springs are especially recommended in dyspepsia. During the author's sojourn at the springs, he had abundant opportunity to test the virtues of the Soda Springs in his own person and in that of one of his travelling companions. A glass of this water will almost instantly give relief in pyrosis, acid eructations, or flatulence, and its habitual use prevents the recurrence of these disagreeable symptoms. They are further of decided benefit in renal and bladder disorders. The waters of the Soda Springs, being clear, sparkling, and very palatable, form an excellent table beverage. The iron waters are highly beneficial in debility, in early phthisis, and in anæmia and chlorosis. Numerous excellent hotels and boarding-houses are maintained at Manitou Springs. The visitor will find all the arrangements for his comfort and well-being equal to any that may be found at a first-class Eastern resort. *James K. Crook.*

MANNA.—"The concrete, saccharine exudation of *Fraxinus Ornus* L. (fam. *Oleaceæ*)" (U. S. P.). Numerous other varieties of manna than this, the official one, are known, and some of them will be noticed at the close of this article.

This, the manna-ash of Italy, Sicily, Asia Minor, etc., is a small, graceful tree, with smooth gray bark, slender branches, odd pinnate leaves, and the characteristic inflorescences and fruit of the genus. It grows to about twenty feet in height, and is often cultivated, both in and beyond its natural habitat, for ornament, but does not yield manna excepting in Southern climates. In Sicily, whence most of the manna of the present time comes, the trees are regularly cultivated for this purpose, being planted in rows in "orchards," and allowed to grow unmolested until the stems are nearly as large as the leg. Then the tapping is begun, and repeated every summer for a dozen or more years, until the tree is exhausted. The usual method is to make a transverse cut through the bark near the base of the trunk, and to follow it each day with another, about an inch higher up than the last, during favorable weather. It is done in the middle of the summer, and hot, dry days are essential to success. The sap exudes from these cuts—a thick, syrupy, very clear, and sweet liquid—and soon concretes on the bark of the trunk, or on leaves, sticks, straws, etc., laid for it. These lumps are either cut or "flaked" off, great care being taken not to get any of the bark, and in this state they constitute the highly prized "Flake-manna," which is graded in sizes. The exuding tears often drop to the ground, and sometimes form large masses at the base of the trunk. This, with the scrapings from the trunks, is assorted into inferior grades, "small flake," "sorts," "cake manna," etc., some of which are very impure.

DESCRIPTION.—Manna suitable for medicinal use is thus described in the Pharmacopœia: "In flattish, somewhat three-edged pieces, occasionally eight inches (20 cm.) long, and two inches (5 cm.) broad, usually smaller; friable; externally yellowish-white, internally white, porous, and crystalline; or in fragments of different sizes, brownish-white, and somewhat glutinous on the surface, internally white and crystalline; odor, honey-like; taste sweet, slightly bitter, and faintly acrid. On heating 5 parts of manna with 100 parts of alcohol to boiling, and filtering, the filtrate should rapidly deposit separate crystals of mannit. Manna consisting of brownish, viscid masses containing few or no fragments of a crystalline structure should be rejected." There is much opportunity for economy in purchasing a good grade of manna, without selecting the very high-priced flakes, which are superior in appearance only.

COMPOSITION.—Fine qualities of this drug contain seventy or eighty per cent. of *mannit* ($C_6H_8[OH]^6$), a sweet, crystalline, sugar-like, peculiar substance, also found in other sweet saps. There are also traces of *fraxin*, a neutral bitter substance which is found in the bark of several other species of ash, and which injuriously affects the quality.

ACTION AND USE.—The best (not bitter) specimens of manna contain nothing of importance besides this *mannit*. They are not poisonous or deleterious in any quantity, and exert on the human body simply the influence of a very gentle catharsis. Manna has been for a long time a favorite laxative for infants and children, on account of its pleasant taste, but it is becoming scarcer and is used less and less frequently. Dose (adult), from 25 to 50 gm. (℥ i. ad ℥ iss.), which may be taken in substance or dissolved in water. The only official preparation is the compound Infusion of Senna (*Infusum Sennæ Compositum*, U. S. P.), made as follows: Senna, 6 parts; manna, 12 parts; sulphate of magnesium, 12 parts; fennel, bruised, 2 parts; boiling water, 80 parts; water. Macerate, strain, and add water enough to make 100 parts—a cathartic.

The name "manna" has been applied to a number of sweet exudations from trees and plants which grow in various parts of the world. *Fraxinus excelsior* L., the common European ash, like many others of the genus, yields a sweet sap, and is said to yield a little manna in Sicily. Alhagi manna, from a small leguminous plant of

*Dr. L. D. Sebree gives us the following temperatures for the winter months: November, 48°; December, 43°; January, 40°; February, 48°; March, 50°; April, 64°. These records were made at 12 noon. At 6 P.M. the temperature was twelve to fifteen degrees lower. There was no rain from November 11th to March 15th.

India, is in small, roundish, hard tears. Tamarisk manna, from Arabia and Persia, is also in small tears. "Shir Khist" is from a species of *Cotoneaster*, collected in India; oak manna, from several species of oak, and Briançon manna, from the larch. None of these has, however, in European markets, any importance as compared with the variety here described. *Henry H. Rusby.*

MARDELA SPRINGS.—Wicomico County, Maryland.
POST-OFFICE.—Mardela Springs. Hotel.

This resort is located on the Baltimore, Chesapeake and Atlantic Railroad, twelve miles west of Saulsbury. Under the name of Barren Creek Springs they have been used for medicinal purposes for many years. There is much charming scenery in the neighborhood, and the atmospheric conditions during the summer months are of a very desirable character. The location is about two hundred feet above the sea-level. Messrs. Taylor and Bacon, of the springs, supply us with the following analysis by Prof. P. B. Wilson, of the Baltimore University School of Medicine:

ONE UNITED STATES GALLON CONTAINS:

Solids.	Grains.
Silica	1.28
Arsenious acid	Strong trace
Ferric oxide (iron sesquioxide)	11.50
Alumina	.34
Sodium chloride	.78
Calcium carbonate	1.35
Magnesium carbonate	.04
Calcium sulphate	.01
Sodium carbonate	Trace
Total	15.30

The water is a strong chalybeate. It is a very efficient tonic and diuretic, and contains sufficient arsenic to give it valuable alterative properties. It promotes the appetite, aids the digestion, and increases the general powers of nutrition. It is highly recommended by physicians of Baltimore in cases of weakness and irritability of the bladder, anæmia, and chlorosis, dyspepsia, chronic cystitis, and urethritis, and in amenorrhœa, leucorrhœa, and other functional disorders of the female pelvic organs when due to debility. The water is found in the Baltimore markets. *James K. Crook.*

MARIENBAD.—"This is a well-known Bohemian spa, lying in a pleasant valley, surrounded by forest-covered hills, not far from Carlsbad. Its elevation is about 2,000 feet above the level of the sea. There are eight springs known as the Kreuz-, Ferdinands-, Carolinen-, and Ambrosius-Brunnen, and the Wald-, Wiesen-, Rudolfs-, and Marien-Quelle. Of these the most important are the two first mentioned. The following is the composition of four of the springs, according to analyses made at different times by different chemists. The proportions of the solid constituents are given in grams per litre.

	Kreuz-brunnen.	Ambrosius-brunnen.	Wald-quelle.	Rudolfs-quelle.
Sodium sulphate	3.873	0.275	1.06	0.11
Potassium sulphate	.054	....	.20	.02
Sodium chloride	1.237	.075	.37	.06
Sodium carbonate	.995	.115	1.00	.14
Calcium carbonate	.556	.270	.38	1.12
Magnesium carbonate	....	....	.40	.67
Aluminum carbonate	.405	.200	....	....
Lithium carbonate	.005	....	....	....
Strontium carbonate	.001	....	....	....
Ferrous carbonate	.040	.035	.02	.04
Manganous carbonate	Trace.	....	Trace.	.07
Aluminum and calcium phosphates	.001	....	....	.03
Silicic acid	.007	.050	.10	.01
Bromides, fluorides, organic matters, etc	Traces.	Traces.	Traces.	Traces.
Total solid constituents	7.174	1.020	3.53	2.27

"The springs all contain a certain proportion of carbonic-acid gas. They are employed for the greater part internally. The Marienquelle, however, is used for bathing; it is very weak in solid constituents, containing only 0.182 part per thousand, but is pleasantly carbonated.

"The waters of Marienbad are prescribed in cases of abdominal plethora, gout, hemorrhoids, chronic dysentery, hepatic congestion, etc., occurring in well-to-do individuals accustomed to indulge rather freely in the pleasures of the table. They are also very useful in obesity, and are especially recommended in affections associated with the menopause. The waters of some of the springs have considerable reputation in the treatment of neuralgia and of chronic catarrhal troubles of the respiratory organs and bladder. Ordinary baths are not much employed, though gas- and mud-baths are made use of to some extent. The season at Marienbad lasts from the beginning of May to the beginning of October. The climate is not mild, yet not disagreeably raw. The waters are exported in very large quantities. This spa is much frequented, the average number of guests each year being 21,000." *

[Obesity is "the great specialty here," and corpulence stalks abroad on every hand. When one, however, has rid himself of his superabundant adipose tissue, great care must be paid to the diet, else the "too, too solid" fat will not remain melted. The accommodations are abundant and good; there is an English and Scotch church service, and there are over forty doctors. Marienbad is reached from London viâ Cologne, Nuremberg and Eger in thirty hours.—*Edward O. Otis.*]

MARIETTA, GEORGIA.—Situated in the northwestern part of the State, twenty miles from Atlanta, at an elevation of from 1,100 to 1,200 feet above sea-level. It is a town of some 3,384 inhabitants, with a dry sandy soil, and an invigorating climate with a large proportion of sunny days. In 1888, there were 263 sunny days, and 102 rainy or cloudy days. For the same year the average minimum and maximum monthly temperatures, the extremes of temperature, and the rainfall were as follows for the months of October to May.

	Average minimum temperature of month. Degrees.	Average maximum temperature of month. Degrees.	Maximum temperature. Degrees.	Minimum temperature. Degrees.	Rainfall. Inches.
October	49	64	77	37	3.93
November	44	58	75	26	4.38
December	34	49	64	18	4.97
January	36	49	72	12	3.10
February	40	54	69	10	4.00
March	39	58	77	19	9.81
April	52	73	82	42	1.68
May	57	74	85	41	5.13

The average yearly temperature is 57.66° F.

There are no humidity statistics known to the writer, but at Atlanta, twenty miles distant, the average relative humidity, as ascertained from observations taken at 8 A.M. and 8 P.M., is 71.8 per cent., with an average mean yearly temperature of 60.7° F.

It is said to be a breezy region, but there are no wind storms or fogs. Malaria does not exist here. There are two hotels, well kept, quiet, and comfortable, good boarding-houses, and a few houses for rent. The summer climate is also said to be "delightful," and the place is much resorted to at that season. Marietta is easily reached from New York and Washington viâ the Great Southern mail route. *Edward O. Otis.*

MARJORUM. See *Labiatæ.*

MARKASOL is bismuth borophenate, an antiseptic dusting powder. *W. A. Bastedo.*

* From the former edition of the HANDBOOK.

MARK WEST SPRINGS.—Sonoma County, California. Hotel and cottages.

This resort is situated eight miles from Santa Rosa, near the famous "Petrified Forest" on Mark West Creek. It is reached by rail to Calistoga or Santa Rosa, and thence by carriage or stage over a picturesque drive to the springs. The mountain region along the road is coming under a high state of cultivation, and beautiful villas and private mountain retreats are springing up in all directions. The springs are beautifully located at an elevation of 800 feet in a small valley formed by the junction of four canyons. The hotel and grounds are at the bases of three venerable mountains known as Mount Washington, Mount Lincoln, and Mount Grant. The air is clear and dry, the temperature ranging from 80° to 90° F., with cool, bracing sea breezes. There are excellent hotel accommodations and several cottages for family use. Hot sulphur and mud baths have been constructed, with all facilities for the comfort of the visitor or invalid. There are several springs on the place, one of them a sulphur spring, yielding about 200 gallons per hour. The temperature of the water is 82° F. It contains: Sulphate of sodium, sulphate of magnesium, salts of potassium (trace), chloride of sodium, carbonate of sodium, carbonate of potassium, carbonate of lime, silica, alumina, free carbonic-acid gas, sulphureted hydrogen gas.

There is also a strong chalybeate spring, yielding 600 gallons of water per hour, having a temperature of 65° F. The largest spring has a flow of 5,000 gallons hourly; this is a sparkling carbonated water, very palatable, and gently aperient in its action. The water at these springs has been found useful in a considerable variety of affections. The baths are sulphurous. *James K. Crook.*

MARSHMALLOW.—Althæa. "The root of *Althæa officinalis* L. (fam. *Malvaceæ*)" (U. S. P). The Marshmallow is a tall, perennial salt-marsh herb of temperate European sea coasts. It is also largely cultivated, sometimes for ornament, but chiefly for its root, in Southern Europe. The root of commerce is from six inches to nearly a foot long, usually about half an inch in greatest thickness, simple and regularly tapering. It is nearly white, from the removal of the outer bark, and marked with several broad grooves and numerous small, brown, slightly elevated spots. It is more or less fuzzy with long, hair-like, partly detached bast fibres. It snaps readily, owing to its large amount of starchy parenchyma, but the parts still cling together by their tough bast fibres. It has a sweetish and strongly mucilaginous taste. It is about one-third gum and another third starch, with about ten per cent. of pectin, eight per cent. of sugar and one per cent. of asparagin. Its properties are wholly nutritive and demulcent. There is no pleasanter adjuvant than the official *Syrupus Althææ*, of five-per-cent. strength.

The leaves and flowers are also rich in gum, and both are much used in domestic practice in Europe for poultices and demulcent drinks. *Henry H. Rusby.*

MASSAGE.—Definition.—Massage (from the Greek, *masso*, I knead or handle; Arabic *mas'h*, press softly; Sanskrit, *makch*, to strike, to press, to condense) is a term generally accepted to signify a group of procedures which are best done with the hands, such as friction, kneading and manipulating, rolling and percussing the external tissues of the body in a variety of ways with either a curative, palliative, or hygienic object in view. In many cases massage should be combined with movements, passive or active, assistive or resistive, as may be required, and these are often spoken of as the Swedish movement cure. Most scientific men prefer to have the word massage embrace all these varied forms of manual therapeutics, for the reason that the word cure attached to any form of treatment whatsoever is often misleading.

History.—Massage, in some crude form or other, has been used from time immemorial by savage and civilized people, because it is founded on instinct. The history of massage is coeval with that of mankind, and those who have thought it worth while to record their appreciation of it have in almost every instance been men of eminence either as physicians or as philosophers, poets, or historians. The aphorisms of Hippocrates embodied the wisdom of the past and presaged the developments of the future to a greater extent than most ancient or modern writers on massage have shown any evidence of understanding. He says: "The physician must be experienced in many things, but assuredly also in *anatripsis*, the art of rubbing up; for things that have the same name have not always the same effects. For rubbing can bind a joint that is too loose and loosen a joint that is too rigid. Rubbing can bind and loosen; can make flesh and cause parts to waste. Hard rubbing binds; soft rubbing loosens; much rubbing causes parts to waste; moderate rubbing makes them grow." The results which he has predicted will follow when the necessary previous conditions have existed.

Amongst the old Greeks and Romans massage in some form or other was patronized by people of widely different classes, from the patricians, the wealthy and the learned down to poor decrepit old slaves; and for the most diverse purposes: with some as a means of hastening tedious convalescence, with others as a luxury in conjunction with the baths, and with still others to render their tissues supple and enduring preparatory to undergoing feats of strength, so that there would be less likelihood of sprains and ruptures.

To Peter Henrik Ling, of Sweden, credit is given for having instituted what is so well known as the "Swedish Movement Cure." In 1813 the Royal Central Gymnastic Institution was established at Stockholm in order that Ling might practise and teach his gymnastics, which were adapted to the well and the sick. The critics of Ling quickly brought forward testimony to prove that his method was but a revival of that of the ancients. But, however his genius and the claims of priority made for him may have been disputed, there was no doubt as to the merits of the system which he rescued from oblivion. In some of the large cities of this and other countries, institutions similar to the one at Stockholm exist where movements and stirring up of the external tissues of the body by hand and by machinery are employed. When they rely too much on machinery for this purpose their existence is generally brief.

The field of usefulness of massage has gradually been extending, so that now it has found its way into every general and special branch of medicine, frequently meeting with signal success after the apparent failure of every other means. He who would understand this art, its indications and contraindications in all their ramifications, ought to be a well-informed man. Dr. J. Zabludowski is a full professor of massage at the University of Berlin, and the force of circumstances requires that he should not be the least learned man of the faculty.

Mode of Applying Massage.—Vague generalities still exist as to the best manner of doing massage; and these are not rendered clearer by calling slow and gentle stroking, *effleurage;* or by speaking of deep rubbing as *massage à friction;* or by using the word *pétrissage* for manipulation or kneading without friction; or by calling percussion, *tapotement.* These and other subdivisions of massage can all be grouped under four heads: friction, percussion, pressure, and movement. Manipulation, malaxation, deep rubbing, or kneading is a combination of pressure and movement without allowing the hand to slip on the skin. It is of more value than all the other procedures, and constitutes the massage, properly so called, of the older writers and also of the later ones who know anything about it. Each and all of these may be gentle, moderate, or vigorous. Some general remarks will save repetition. 1. All of the single or combined procedures should at first be begun moderately, then gradually increased in force and frequency to the fullest extent desirable, and should end gradually as begun. 2. The greatest extent of the hands and fingers of the manipulator, consistent with ease and efficacy of movement, should be adapted to the surface worked upon, in order

that no time shall be lost by working with the ends of the fingers, or with one portion of the hands, when all the rest might be occupied. 3. The manipulator, if too near the patient, will be cramped in his movements; if he is too far away, they will be lacking in energy, indefinite, and superficial. 4. The patient should be in an easy and comfortable position, with joints midway between flexion and extension, in a well-ventilated room, at a temperature of 70° to 75° F. Any sensations of tickling will soon disappear when firm, steady, deep kneading is employed. 5. The directions of these procedures usually should be from the insertion to the origin of the muscles, from the extremities to the trunk, in the direction of the returning currents of blood and lymph, unless there be a plug in a vein. 6. What constitutes the dose of massage is to be determined by the force and frequency of the manipulations, and by the length of time during which they are employed, considered with regard to their effect upon the patient; in other words, the reaction must be studied. A good manipulator will do more in fifteen minutes than a poor one in an hour, just as an old mechanic working deliberately will accomplish more than an inexperienced one working furiously.

In using friction upon the limbs, after the strong upward stroke, the hand should return gently grazing the surface, so as to impart a soothing sensation; it should not press upon the parts so vigorously as to retard the currents pushed along by the upward stroke; and thus a saving of time and effort will be gained. The manner in which a carpenter uses his plane represents this to-and-fro movement very well. Six to a dozen or more of these up-strokes and as many returning may be used at a time, according to the effect desired. On the hands and feet the friction may be done in a rectilinear manner, parallel to the long axis of the limb, and on the arms and legs it can be used not only in straight lines but also by long oval strokes extending from joint to joint, the strong stroke up, the light one returning. It is well to begin these strokes on the inner side of both arms and legs so that the larger superficial and deep vessels may first be emptied, as this makes room for their tributaries to pour their contents into them. From the base of the skull to the spine of the scapula forms a well-bounded region for downward and outward semicircular friction; and from the spine of the scapula to the base of the sacrum forms another surface over which one hand can sweep in downward and outward strokes, alternating with those of the hand at work upon the shoulder, the patient for this purpose lying on the opposite side. The application of friction to the hip should be done in an upward direction with alternate strokes from the insertion to the origin of the glutei; to the chest, from the insertion to the origin of the pectoral muscles; and to the abdomen, from the right iliac fossa in the direction of the ascending transverse and descending colon. Friction over the stomach should be upward and inward from the left side, and over the liver, up and in from the right side.

For manipulation or kneading the same division of surfaces and direction of working should be made as for friction; and it is a very good rule, but not an absolute one, that stroking and kneading should alternate. Adapting as much as possible of hands and fingers to the part to be *masséed*, making three manipulations and passing three times over a surface, as from wrist to elbow, constitute a very good plan; then half a dozen strokes should be made, and so on. The grasps should alternate, one hand contracting as the other relaxes, and the advance on new territory should be such as to permit of the hand overlappping one-half of what was *masséed* at the previous grasp. For this purpose the two hands may encircle a limb, one slightly in advance of the other; or a single group of muscles may be *masséed* at one time by alternate squeezes with each hand.

For manipulation of the back we have the patient lie on one side as for friction, and then, while steadying the head with one hand pressed against the temporal region, we make the fingers of the other work vigorously from the median line upward and outward toward the insertion of the muscles at the base of the skull. The direction of the manipulations on the rest of the back should generally be downward and outward from the spine in graceful curves, and on the hip upward and outward, the two hands alternating in the same direction. On large people with very firm tissues, one hand should often be reënforced by placing the other upon it, the *masséeing* thus being done with all the strength that can be put forth. The force used here and elsewhere must be carefully graduated so as to allow the patient's tissues to glide freely over each other; for if it be too great the movement will be frustrated by the compression and perhaps bruising of the patient's tissues; if it is too light the manipulator's fingers will slip; and if gliding with strong compression be used the skin will be chafed. In order to avoid this last objection, which is almost a universal error, greasy substances are employed, so that would-be masseurs may rub without injuring the skin. When the skin is cold and dry, or cold and moist, and insufficiently nourished, as in certain fevers and other morbid conditions, there is no doubt of the value of inunction; but no special skill is required to do this. Removal of hair is also unnecessary; for massage can be done as effectually on the head as on any other part.

On the chest and abdomen the same general direction will be observed for manipulation as for friction, but the pressure will be more gentle than on the back and limbs, as the tissues here will not tolerate being so strongly squeezed. On the chest, alternate circular kneading may be done with one hand on each side; or one side may be done with both hands, one at the upper, the other at the lower part, the direction of the circular kneading being down, in, out. On the abdomen, firm, deep kneading is usually best in the direction of the colon, the greatest force being used with the heel of the hand on the side of the abdomen next the operator, and on the other side the strongest manipulation being made with the fingers, care being taken to avoid the frequent and disagreeable mistake of pressing at the same time on the anterior parts of the pelvis.

Percussion, often useful for relaxed muscles, may be done in a variety of ways. In the order of their importance they are as follows: 1. With the ulnar borders of the hands and fingers. 2. The same as the first, but with the fingers separated. 3. With the tip ends of the fingers united. 4. With the palms of the hands. 5. With the ulnar borders of the fists. 6. With the palms of the hands held in a concave manner so as to compress the air while striking. The blows should be smart, quick, and springy, and usually with the ulnar borders of the hands directed transversely to the muscular fibres; except in the case of the back, which may not only be percussed with the hands at right angles to it while the patient lies face down, but also still more effectually when the patient stands slightly bent forward so as to put the dorsal muscles on the stretch. The hands of the percussor are then most easily held parallel to the spinal column, and can rapidly strike the muscles on each side of it, causing, we have every reason to suppose, a vibratory effect as when the string of a bow is struck. Moreover, in this position, the muscles, being tense, protect the transverse processes from the impact which the blows communicate to the roots of the nerves as they emerge from the intervertebral foramina, and the vibratory effect of this upon the distribution of the nerves is perceived as a peculiarly delightful and agreeable thrill.

Remedial movements, wrongly called medical gymnastics, have been more fully than clearly described in books on "Movement Cure." According to the descriptions of them which I have read the patients would have to be made for the movements rather than the movements adapted to the patients. Passive movements should be given to parts which the patient cannot move; assistive movements when the patient can do but a part and not the whole of a movement; resistive movements, when the patient is strong enough to oppose resistance for the purpose of cultivating increase of strength. Much learned nonsense has of late been written about various move-

ments and these have been given the names of their advocates. The truth simply amounts to this: find out what the patient can do and gradually increase this in such a manner as to invigorate and not fatigue. The inventive genius of any one may thus be called into play. Except in the case of relaxed joints passive motion should be employed in the treatment of joints which have been too long at rest until a degree of resistance is exerted by the patient which is perceptible to the manipulator; for this is the only way in which we can know that the natural attachments of the joints are being acted upon. Resistive movements are of two kinds: those which the patient can make against the efforts of the operator, and those which the operator overcomes while the patient resists, as when a group of muscles is voluntarily contracted and then pulled out into extension against the patient's resistance. The former have been called double concentric, the latter double eccentric by some eccentric individuals. When muscles are very weak, and it seems desirable to exercise them, it is better that they should first be contracted to their utmost, for then they can put forth much more strength in resisting extension than they could in passing from relaxation to contraction. Most frequently, however, it will be necessary to make resistance against the contraction of the patient's muscles, and then the opposing force should be kept carefully and instinctively within the limits of the patient's strength, so that he may not recognize any weakness; and this, with all the other procedures, should stop short of fatigue, at least such fatigue as is not soon recovered from. To resist alternately flexion and extension is the *pons asinorum* of manipulators, and in a long experience of teaching massage I have found but few who could learn to do this well, and many who could not learn to do it at all. Many a patient who has recovered from an old injury is still as much incapacitated as ever, from the fact that his latent energies can be discovered and cultivated for greater use only in this manner.

Midway between passive and resistive movements in the course of certain recoveries come assistive movements. They are but little understood and seldom used, the patient being credited with complete loss of the power of motion. For instance, in the absence of completely and permanently disabling injury or disease, let it be supposed that the deltoid has but one-half the requisite strength to elevate the upper arm. So far as any use is concerned, this is practically the same as if no power of contraction were left in the muscle. But if only the other half of the impaired vigor be supplied by the carefully graduated assistance of the manipulator, the required movement will take place; and in some cases if this be regularly persisted in, together with manipulation and percussion of the faulty muscle, more vigorous contraction will be gained, and by and by the patient will exert three-fourths of the necessary strength, and later the whole movement will be done without aid; and as strength increases, even resistance may be opposed to the movement. The importance of these measures can hardly be overestimated in cultivating the strength of weakened muscles, while at the same time we find out how much they can be used. Still another kind of movement deserves mention here, namely, vigorous passive motion with a view of breaking up adhesions in and around joints. It is the secret of success and of failure of people who call themselves "bone-setters."

Physiological Effects of Massage.—The pressure of massage exerts a simultaneous influence upon all the tissues within its reach—upon skin, fasciæ, muscles, blood-vessels, lymphatics, and nerves.

Skin.—Tough, flexible, and elastic as the skin should be in its natural condition, owing to the white fibrous and elastic tissues entering into its composition, it is rendered none the less so by a prolonged course of massage. While it becomes softer, more supple, and finer under massage, it also at the same time becomes more tough, flexible, and elastic, so that whereas at the beginning of massage it could scarcely be pinched and grasped without pain, later on, the patient will almost allow himself to be lifted up by the skin like one of the agile domestic animals; thus showing a marked change in the sensibility of these parts. The soothing effect of gentle stroking is familiar to every one, and the analgesic or agreeably benumbing influence which follows vigorous pinching is also well known. These peculiarities can often be utilized in gradually approaching painful places which could not have been directly pressed upon.

Muscles.—After massage muscles are more supple and comfortable, have greater power of endurance, and respond more readily to the will, to the faradic and to the galvanic current than they did before. When fatigued they recover more rapidly under massage than they do under the influence of rest alone, and are capable of doing about twice as much work as they can after resting for the same length of time. Dr. Zabludowski, professor of massage at the University of Berlin, found the effects of general massage on healthy people to be an elevation of the functions of life in general, and with an improved frame of mind were associated easier movements of body, increase of muscular strength, greater appetite, more vigorous and regular action of the large intestines, and more profound and refreshing sleep. Professor Maggiora, of the University of Turin, by an interesting and accurate series of experiments, has demonstrated the restorative effects of massage upon his own muscles when fatigued and weakened by physical or mental labor, by electricity, by hunger, by loss of sleep, and by slight fever. For this purpose the fatigue curves of the right and left middle fingers were taken in maximum voluntary flexion every two seconds, the weight employed being one of 3 kgm. The average results showed that the muscles concerned in this movement could do about twice as much work after a few minutes of massage as they could without. When, however, the brachial artery was compressed and the supply of blood shut off, massage had no effect at all. Of the three principal forms of massage, friction and percussion were much alike in the restorative effects produced by each, while *pétrissage*, or kneading, had a much greater influence than either of the others. When all three were used, the greatest effect was obtained. As to the effects gained by the length of time during which the massage was used, he found that a period of five minutes for the finger and for the forearm, brought forth a greater capability of work than when the massage was employed for either a longer or a shorter time.* I have always maintained that manipulation, kneading, or *pétrissage* is of more value than all the other procedures of massage put together.

Flow of Blood and Lymph.—When the contraction and relaxation of muscles no longer take place, the circulation languishes and then the assistance of massage may be invaluable; for by upward friction and deep manipulation the veins and lymphatics are mechanically emptied, the blood and lymph are pushed along more rapidly by the *vis a tergo* of the massage, and these fluids cannot return toward the extremities by reason of the valvular folds on the internal coats of their vessels. More space is thus created for the returning currents coming from beyond the region *masséed*, and the suction power induced at the same time adds another accelerating force to the more distal currents. The effect may well be likened to the combined influence of a suction and a force pump, and in people who are not too fat the superficial veins can be seen collapsing and filling up again as their contents are pushed along by the hands of the masseur. In this way the collateral flow in the deeper vessels, as well as the more distal stream in the capillaries and arterioles, is accelerated and the engorgement relieved. One would naturally suppose that the blood in the larger arteries would thus be interrupted. But herein comes an additional advantage to aid the circulation; for the compression being but momentary causes a dilatation of the arteries from an increased volume of blood above the parts pressed upon, and, as soon as the pressure is removed, this ac-

* Archivio Italiano di Biologia, tome xvi.

cumulation rushes onward with greater force and rapidity in consequence of the force of the heart's action and the resiliency of the arteries acting upon the accumulated volume of blood. Gentle upward stroking, though soothing, is a mild irritant, in a physiological sense, of the superficial vessels, causing a narrowing of their calibre and a stronger and swifter current in them by reason of its stimulating influence on their muscular coat and vaso-motor nerves. But let centripetal stroking, or any other form of massage, be continued for a sufficient length of time, or become stronger, and hyperæmia will result, indicating relaxation of the vascular walls due to over-excitation or exhaustion of the tone of their muscular coat and vaso-motor nerves. Retardation is, however, obviated by the mechanical effect of the massage pushing along the returning current. By reason of the fact that more blood passes through regions *masséed*, there will be an increase in the interchange between the blood and the tissues; and thus the work done by the circulation will be greater and the share borne by each factor less.

Dr. Brunton has shown by means of a glass tube inserted into a blood-vessel that the blood passes three times more rapidly through a part while it is being *masséed* than when it is not. The fact that the peripheral circulation is thus helped along in so appreciable a degree lessens the work of the heart in pumping it around, and makes it easy to understand why massage is so useful in nearly all forms of cardiac trouble. Dr. J. K. Mitchell has found that in many cases after massage there was a great increase in the number of red globules and of the hæmoglobin also. Dr. Oliver, of London, has pointed out that any influence causing rise of blood pressure would slightly concentrate the blood. In view of Mosso's discovery that when the blood of a fatigued animal is injected into another at rest, symptoms of fatigue are induced in the latter, it is not unlikely that when massage is applied to a fatigued person the blood of this individual resumes the condition of that which it has when he is rested, for massage certainly dispels fatigue, often very quickly.

In all the experiments which have been made in dogs for the purpose of determining the rapidity of flow of the lymph stream—by the insertion of a glass tube either into the thoracic duct or into the large lymph vessel which accompanies the saphenous vein—it was found that the activity of the flow was greatly increased by means of massage and passive motion, much more so than when galvanism was used; and it was also observed that in cases of inflammation the flow was much more abundant than it was from healthy parts.

Upon the nervous system as a whole, massage usually exerts a peculiarly delightful and at the same time decidedly sedative and tonic effect. While it is being done, and often for hours afterward, those who submit to it are in a blissful state of repose; they feel in a short time as if they were enjoying a long rest, or as if they had just returned from a refreshing vacation; it makes optimists of them for the time being. An aptitude for rest or for work generally follows. Those who submit to this treatment experience a sense of relief from the apprehensions which previously distressed them. No unpleasant after-effects ever follow the judicious employment of massage. Through the medium of the central nervous system the effects of even a local massage are radiated or reflected throughout the body, thus acting as a nervous and vascular revulsive. The transmitted and reflected influences of massage are as extensive as the distributions and connections of the sensitive nerves that are accessible to its impressions. From mechanical impressions like massage upon sensitive nerves in their connections with other sensitive nerves we may expect to get modifications of sensation; through the connections of sensitive nerves with motor nerves we may expect to see an influence exerted upon motion; and, finally, through the relations which the nerves directly affected by massage bear to secretory and inhibitory nerve fibres, we may also expect that this therapeutic procedure will cause changes to take place in the functions of secretion and nervous inhibition.

The Different Diseases in which Massage May be Employed to Advantage.

Neurasthenia.—If space permitted I could report cases sufficient to prove: 1. That massage induces sleep.

2. That even when it is applied in the forenoon the soporific effects may not disappear before bedtime; though in general the later in the day it is used for promoting sleep the better.

3. When massage is administered in the forenoon the development, at some later period of the day, of a disagreeable feeling of drowsiness and languor need not necessarily interfere with sound sleep at night. Aptitude for rest or for work generally follows massage. The mind is clearer and in a better condition for prolonged and effective work, and the muscles do not tire so soon.

4. When people are wakeful after massage they are not likely to be restless or to feel the loss of sleep on the following day.

5. Spinal irritation is relieved or disappears under massage.

6. For local neurasthenia there is no need of general massage, unless the whole system be secondarily affected.

7. When affections have come to a standstill under massage, improvement may yet go on after the manipulations have been discontinued.

8. As a means of improving the nutrition of nerves and muscles, and of restoring natural sensation and motion, massage may succeed when other means have failed.

9. Deep massage without friction has proved, in suitable cases, of more value in my hands than all other forms of massage put together.

10. Massage can be overdone; in which event the effects produced will be the opposite of those which follow a moderate use of this therapeutic procedure.

11. Besides massage, carefully graduated exercises at regular times are valuable accessories in the restoration of motion.

12. Massage is not the only means of treatment for neurasthenia. Its selection is usually decided upon after the failure or the exhaustion of every other means.

Writer's Cramp and Allied Affections.—Overuse of nerves and muscles, especially in fine work requiring a high degree of delicate co-ordination of voluntary impulses and individual movements, as in writing, sewing, knitting, watch-making, playing the piano, harp or violin, gives rise, especially in those who are somewhat neurasthenic, to disorders similar to the affection known as writer's cramp. So does also, but less frequently, excessive use of muscles in heavier occupations, such as painting, telegraphing, tailoring, shoemaking, blacksmithing, and milking, occasion like disturbances of sensation and motion. The predominating symptoms may be of a spastic, tremulous, or paralytic form, accompanied by extreme fatigue, pain, formication, hyperæsthesia or anæsthesia, and thrills like electricity. There may be partial or total inability to perform the accustomed movements; if they be attempted for but a few minutes the symptoms named may arise. The spasm may affect either the flexors or the extensors; there may be rigidity or contraction of the muscles, local or general tremor. No two cases are exactly alike, as these symptoms are variously combined. As a rule, they develop only when an attempt is made to resume the work that brought them on, while for all other purposes the hands and arms are as good as ever. Recent and slight cases are almost invariably cured by massage and suitable exercises. But it is quite otherwise with those of long standing, unless the physician can discover some causal objective points—such as neuritis, a painful scar, or bad writing materials—the removal of which would expedite recovery.

Chorea.—Encouraging success has attended the systematic use of massage and gymnastics in chorea. It is generally agreed that the seat of the malady is for the most part in the brain, though the spinal cord and peripheral nerves may share in the disorder, which is of such a nature as to weaken the force of the nervous system without destroying it. Recent investigations seem to show

that the erratic movements are due to organic change in the brain and spinal cord. That these have been benefited or cured by massage is strong proof of its far-reaching and powerful influence, extending from periphery to centre. Rest, massage, and abundance of easily digested food have proved successful in the early or acute stage; and in the decline of the malady, when slight irregular movements still linger, massage, exercise, and calisthenics have done well. In 1847 Laisné, of Paris, treated one hundred and eight cases of chorea by means of massage with almost invariably good results. Drs. Goodhart and Phillips, of London, have treated a number of acute cases of chorea by massage, suitable nourishment, and rest, and the advantages proved to be that when the massage was carefully performed, flabby and thin muscles became plump and firm. Marked improvement was observed in every case in the rapid subsidence of all the more violent movements; in improved circulation and warmth of the extremities; in the pulse becoming more regular; in the patients sleeping soundly after the massage; and in their decided increase in weight. The massage was given for fifteen minutes, twice daily.

Neuralgia and Neuritis.—In neuralgias of mild form, and in what seem to be the incipient stages of more severe attacks, as well as in old cases, in which every other remedial measure has been tried in vain, massage often yields favorable results. Used between the paroxysms of severe neuralgic pains, it generally lengthens the intervals between these attacks and lessens their severity. Pain arising from disturbance in the central nervous system is frequently relieved by massage. In cases of peripheral neuralgia when the affected nerves can be reached, massage may be expected to produce still better results. In well-marked degeneration of nerves, and when pain is dependent upon mechanical pressure that cannot be removed, we should naturally not expect any result.

The late Dr. Symons Eccles, of London, has treated successfully a number of cases of acute sciatic neuritis occurring in previously healthy people by means of massage, position, and rest. The massage consisted of effleurage, kneading, and percussion, and in the intervals the leg was suspended in a Salter swing, as this was the only position that afforded rest. Prof. Max Schuller, of Berlin, prefers massage to any other means in the treatment of sciatica. Of fifteen cases that were dealt with from the first by massage, he found that the severe pains soon abated, becoming less even after a severe and painful massage. When they recurred they were less severe, and gradually they disappeared altogether. It required eighteen days on an average for cure. We seldom hear of massage being tried in acute neuritis in the United States.

Affections of the Central Nervous System.—When paralysis of central origin has come on suddenly, I prefer to abstain from the use of massage until the perturbation in general has subsided and the patient has become somewhat accustomed to his unnatural condition. But in the mean time, while we are thus waiting to spare the nerve centres any supposed extra commotion, the peripheral pathological changes are gaining ground. These are: interference with the supply and return of the circulation owing to the accelerating influences of muscular contraction and relaxation being absent or diminished; and, as a result of this, variations of temperature, and passive hyperæmia and ischæmia; hypertrophy of interstitial connective tissue, with subsequent cicatricial retraction, giving rise to contractures and atrophy of muscular fibres; formation of adipose tissue and fatty degeneration; in a word, vaso-motor and trophic disturbances. These are all rational indications for the use of massage, either as a preventive of such changes or as a palliative of them when they have occurred. But if the nerve centres are impaired beyond recovery, or secondary pathological changes have already taken place, the prospect of recovery cannot be encouraging. My own experience with massage in a number of cases of paralysis may be briefly stated by saying that in the absence of severe pain, obstinate contracture, or tonic spasm this agent has proved useful in improving the circulation, temperature, and comfort of the parts affected. When, in paralysis of spinal or cerebral origin, recovery has followed under manipulation, I have always hitherto assumed that the central disturbance had entirely passed away and that the force of habit was the main factor in perpetuating the external manifestations of inaction. But the more recent experiences and opinions of Dr. Zabludowski, professor of massage at the University of Berlin, and of others well qualified to judge, teach us that it is possible by means of massage and gymnastics to educate other parts of the brain and spinal cord, by arousing psychomotor impulses in the formation of new associations and combinations, to take the place of the injured ones. It therefore seems no longer necessary to regard paralysis, of either central or peripheral origin, from the hopeless point of view that we formerly did.

However that may be, when the causative conditions have ceased, paralyzed muscles will not at once resume their former natural condition. Massage, passive and resistive movements, restore them to a sense of existence, enable them to recognize the power they still possess, and educate this to a higher degree, and at the same time such treatment affords the only means of judging of the capabilities of the patient and of telling him how to use them. Sometimes the patient will make better motion against resistance than without it. This seems to give a sense of support and consciousness of power. Interlocking the fingers of one hand with the other, so that the well arm can raise the paralyzed one, is a most excellent device, encourages the patient, and educates the unimpaired centres to supplement the deficiency of the injured ones.

Dry Symmetrical Gangrene.—This peculiar malady was first described by Maurice Raynaud, a medical student in Paris in 1862. Observations since then have confirmed his description of this disease, the theory of which is that it is a neurosis characterized by great exaggeration of the excito-motor energy of the parts of the spinal cord that control vaso-motor innervation,—the posterior and lateral gray substance, according to Oppenheim.

If space permitted, cases of my own and of other practitioners might be narrated (see "International Clinics," vol. iv., 1901) which would justify the following conclusions:

1. When massage is of benefit in Raynaud's disease, it shows its effects very quickly.

2. These effects are improvement of the circulation and an increased suppleness of the parts, with a corresponding increase of the sense of warmth and comfort.

3. Massage is competent not only to maintain and improve the vitality of the tissues, but it may even effect a complete restoration after destruction of tissue has begun.

4. As the beneficial effects of massage in Raynaud's disease are of a permanent character, this procedure must act not only upon the vaso-motor nerves of the affected parts, but also upon their central connections in the brain and spinal cord.

Sprains, Fractures, Displaced Semilunar Cartilages.—When massage is employed sprains of all degrees of severity get well in one-third of the time ordinarily required in cases of this nature. The sooner after the injury massage is begun the speedier is the recovery. Friction and manipulation should be used above and below the injured joint, which should be gradually approached in this manner, and finally worked upon at the same sitting. Fractures unite more quickly when the limb is *masséed* from the first. The immediate advantages are reduction of swelling, pain, and spasm; the remote are less weakness, pain, and stiffness after the bones have united.

Sprains of the knee are sometimes accompanied by derangement of its internal structures, known as displacement of the semilunar cartilages of the knee-joint. If space permitted I could recite cases (see *American Journal of the Medical Sciences*, March, 1896) which have occurred either in my own practice or in that of others, which would seem to justify the following conclusions:

That it is possible by carefully applied massage, resistive movements, home exercises, and electricity so to strengthen the muscles on the front of the thigh, the fasciæ, ligaments, and attachments of the knee-joint, that they will safely hold a previously dislocated semilunar cartilage without artificial support.

These conclusions do not apply to cases which require surgical operations, although the above-mentioned combination of therapeutic procedures might be safely tried in some cases before cutting into a knee-joint. The adoption of massage, however, is more especially called for after the operation, its purpose being to restore motion and strength. *Douglas Graham.*

MASSANETA SPRINGS.—Rockingham County, Virginia.

Post-Office.—Harrisburg. Hotel and cottages.

Access.—Viâ Baltimore and Ohio Railroad to Harrisburg, thence a drive of four and one-half miles southeast to the springs. This resort is located in the Shenandoah Valley, near the Massametten Mountain, at an elevation of 1,350 feet above the sea-level. The waters of the springs have been in use for upward of fifty years, and are still extensively resorted to in the treatment of a variety of affections. They have been analyzed by Professor Mallet, of the University of Virginia, with the following results:

One United States Gallon Contains:

Solids.	Grains.
Calcium carbonate	12.10
Magnesium carbonate	5.78
Iron carbonate	3.12
Manganese carbonate	.43
Sodium carbonate	.93
Lithium carbonate	Trace.
Ammonium chloride	Trace.
Potassium chloride	.13
Potassium sulphate	.09
Calcium sulphate	.35
Alumina	.13
Arsenious oxide (in salt)	Trace.
Phosphoric acid	Trace.
Silica	.94
Organic matter	.40
Total	24.40

Carbonic acid united to carbonates as above to form acid salts. 8.80 grains.
Temperature of water, 55.7° F.

These waters are said to be valuable in the treatment of chronic malarial poisoning, and the managers present numerous testimonials from physicians and others attesting their virtues. It is reasonable to believe, however, that the good effects observed have been in a large measure due to the excellent climatic and sanitary conditions about the springs. The water is an excellent chalybeate tonic, and also has diuretic properties. It is used commercially. *James K. Crook.*

MASSASOIT SPRING.—Hampden County, Massachusetts.

Post-Office.—Springfield. Restaurant at spring.

Access.—Trolley cars from Springfield run within two miles of the spring. The New York, New Haven and Hartford Railroad is within three-quarters of a mile, and the Boston and Albany Railroad tracks are about two miles away. The spring is charmingly located at a point about seven miles from Springfield, in a picturesque glen known as the "Bear Hole." It bubbles from the side of a bluff about 70 feet in height and at an elevation of about 250 feet above the level of the sea. The spring furnishes about 7,500 gallons of water per hour, having a uniform temperature of about 45° F. the year round. With the exception of a restaurant no buildings have been erected for the accommodation of guests, who consist largely of visitors from Springfield, Westfield, Holyoke, Chicopee, and other points during the summer months. The water has been analyzed by Prof. Charles Mayer, chemist, with the following result:

One United States Gallon Contains:

Solids.	Grains.
Sodium chloride	0.36
Lime carbonate	1.38
Magnesium carbonate	.48
Lime sulphate	.25
Silica	.24
Organic substances	.72
Total	3.43

Traces of potash, iron, alumina, phosphates, nitrates.

The water is remarkably free from micro-organisms and ammonia, and contains only a slight trace of nitrates. It closely resembles the waters of the Poland Spring in Maine. It meets all the requirements of a wholesome table water. It is said to be a great aid to feeble digestion and to assist in overcoming obstinate constipation. The water has an extensive sale, and no doubt in time a resort will be established at the spring. *James K. Crook.*

MASSENA OR ST. REGIS SPRINGS.—St. Lawrence County, New York.

Post-Office.—Massena Springs. Hotel.

Access.—Viâ Rochester division of the Rome, Watertown and Ogdensburg Railroad, or viâ Massena Springs branch of Grand Trunk Railroad to Massena Springs Station.

This is one of the old-time resorts of the Empire State. The springs are delightfully situated on the banks of the Raquette River, a broad and rapid stream flowing into the St. Lawrence. The following analysis was made as long ago as 1850 by Prof. W. J. Craw:

One United States Gallon Contains:

Solids.	Grains.
Calcium bicarbonate	4.85
Iron bicarbonate	.49
Sodium hyposulphide	4.21
Sodium sulphate	.50
Calcium sulphate	60.00
Sodium phosphate	1.32
Sodium chloride	76.79
Potassium chloride	.51
Magnesium chloride	29.93
Magnesium bromide	.67
Sodium sulphide	1.40
Organic matter, Silicate of soda	11.18
Total	191.88

Sulphureted hydrogen gas, 5.30 cubic inches.

This analysis indicates that the water belongs to what may be termed the muriated-calcic-alkaline sulphureted variety, but for ordinary purposes the term saline-sulphureted is sufficient. The water resembles that of Eilsen, in the principality of Schaumburg-Lippe, but is much richer in chloride of sodium. It has been found decidedly useful in dartrous forms of skin disease, in renal and vesical calculus, in catarrh of the bladder, and in other affections. Bathing facilities are ample. *James K. Crook.*

MASTERWORT. See *Umbelliferæ.*

MASTIC.—Mastiche. "A concrete resinous exudation from *Pistacia Lentiscus* L. (fam. *Anacardiaceæ*)" (U. S. P.). This is a graceful little tree with slender, brownish-gray branches, and evergreen pinnate leaves. Its flowers are very small, diœcious, in erect axillary spikes; its fruit consists of little, dry, red drupes, about as large as cubebs. Large resin canals exist just beneath the surface of the thin bark, from which a certain amount of turpentine exudes spontaneously. It is widely distributed through the Mediterranean region.

Mastic is a drug of venerable antiquity, being mentioned by the early Greek and Latin writers upon medicine and natural history two thousand years or so ago. It has been kept in use ever since, and several hundred years ago it entered into the formation of numerous medicines and plasters, and was highly prized. It is now fast becoming obsolete, so far as medicine is concerned.

It is collected in the northern part of Scio, whose political fate for centuries depended upon its importance, from cultivated (male) trees planted for the purpose, by making light incisions in the bark, through which it flows in little rounded tears, and on which it slowly hardens in the same shape. Two or three weeks after the tapping, the collectors revisit the trees and collect the little tears from the bark, and from the ground, to which some of them have fallen. This product is afterward sorted, according to whiteness, cleanness, and shape, into several grades, and so sold. The best of that which reaches us is in lemon-yellow tears, of the size of a large pea and smaller. The surface is smooth and free from dust, by which it is distinguished from the dusty tears of sandarac, and the fracture is clear and glassy. Odor and taste pleasantly terebinthinous; texture brittle, but softening in the mouth. Mastic contains one to two per cent. of *essential oil*, about ninety per cent. of *resin*, soluble in alcohol, and ten of another *resin* soluble in ether, but not in alcohol. Mastic is superior when fresh, and this is determined by its degree of plasticity when chewed and by its higher solubility (up to ninety per cent.) in benzol.

The medicinal action of mastic is exactly that of other turpentines, although, perhaps, on a sightly milder scale than the most active of them; that is, it is a local and renal stimulant. It has been, and still is, in the East, employed as a sort of dentifrice, and as a temporary filling for carious and aching teeth. Out of respect to old tradition it is still used in the *Pilulæ Alöes et Mastiches* of the Pharmacopœia, which are one-sixth mastic. It is claimed that the addition of the mastic increases the certainty and promptness of action of the aloes, as of other cathartics.

Oil of mastic, of a clear yellow color, having a specific gravity of 0.858 and the characteristic odor of mastic, is an article of commerce.

ALLIED PRODUCT.—*Pistache* or *Pistacia Nuts* are the seeds of *Pistacia vera* L., obtained chiefly from trees cultivated in the Mediterranean region. This product has no medicinal properties, but is extensively used as an article of food or flavoring by confectioners, in *bonbons* and ices. An emulsion may be made by pounding the seeds with sugar and water, after the manner employed with almonds. This can be used as a pleasant vehicle for more active substances. *Henry H. Rusby.*

MASTICATION.—In order that the digestive juices may act rapidly and efficiently upon the solid food, it is necessary that a large surface should be exposed to their action; otherwise the time of digestion is lengthened and the large lumps of solid matter disturb digestion both by undergoing decomposition and by acting as mechanical irritants to the mucous surface which lines the alimentary canal. The necessary comminution is brought about in the process of mastication by the action of the jaws armed with their various types of teeth, and assisted by the muscular action of the buccinators and tongue.

In addition to being thoroughly subdivided by mastication, the food is intimately admixed with the saliva which is poured out upon it during the process, and so is converted into a soft semi-fluid mass which can easily be swallowed. It has also been recently shown by Pawlow, that efficient mastication, in some reflex fashion, greatly promotes the secretion of gastric juice and so favors peptic digestion. For the quantity of gastric juice secreted is not nearly so great when food is introduced into the stomach through a gastric fistula as when in the same animal it is chewed and swallowed in the natural fashion. Further, in an animal with both an œsophageal and a gastric fistula, in which the food drops out at the œsophagus, after being masticated and swallowed, so that none reaches the stomach, it is found that mastication produces a copious flow of gastric juice.

For these reasons it is obvious that efficient mastication is a great adjunct to the process of digestion, and, although for a time the digestive juices may be able to digest the solid food, even when mastication is defective and the food is swallowed in lumps, yet such a defect in the preparation of the food handicaps the forces of digestion and paves the way for commencing a vicious condition of affairs which may go from bad to worse unless the mastication of the food be improved.

The mouth and not the stomach is, therefore, the first ground which ought to be examined in cases of indigestion, and after that has been, from the mechanical point of view, set in as good order as under the existing circumstances is possible, then the habits of mastication ought to be investigated, and the vicious practice of eating in a hurry and bolting the food in a semi-masticated condition should be eradicated.

It is interesting to observe, as was first pointed out by Cuvier, that a constant relationship exists in different classes of animals between the nature of the food, the form of the teeth, and the articulation of the jaw. Thus, in typical carnivora the teeth are adapted for seizing and lacerating the food, there are no true grinding teeth, and accordingly there are no grinding movements of the lower jaw, which articulates by a simple hinge joint. In herbivora, on the other hand, the nature of the food is such that extensive pounding and grinding are required, and hence the lower jaw is so articulated as to allow of extensive sliding movements from side to side. In this connection, it may be stated that the articulation of the lower jaw in man, not less than his dental series and intermediate length of alimentary canal, demonstrates that he has developed as a mixed feeder capable of masticating both vegetable and animal food, and that a mixture of such foods is his natural provender.

The act of mastication is usually described as a voluntary one, but while this is true in the sense that our eating is under the control of our will, and that we can initiate and arrest the process by acts of volition, still it is well to point out that, like all complex co-ordinated muscular acts, the process is largely a reflex one guided from lower centres, chiefly by an adjusted co-operation of afferent and efferent nerves. Complicated co-ordinated actions of such a type are learned and laid down in the central nervous system in early infancy, and at a conscious age all their details are practically out of the control of the will, so that we walk, talk, and eat without consciously exerting the will over the details of these processes. This has a very practical bearing in regard to mastication, as it gives an explanation of the difficulty attending a reform of the acquired habit of hasty mastication. It is a simple thing to tell a patient who complains of indigestion not to bolt his food, but to eat it slowly, carefully masticating each mouthful, and, if necessary, counting so many before swallowing. But the process has become almost a reflex, and the patient finds the advice, even with all artificial aids, most difficult to carry out; he has to keep his thoughts chained upon the problem all the time he is eating, which to many persons is an impossible task, and so at intervals he unconsciously lapses into bolting his food. Again, when some relief has been obtained and urgency has hence been removed, he no longer can keep his mind at work regulating his eating, and once more the old habit or old reflex becomes established. The problem, in fact, is nearly as difficult as that of breathing at an artificial rate, or altering the depth of the respiratory movements.

The afferent nerve chiefly involved in mastication is the fifth, while the efferent or motor impulses travel by the motor root of the fifth to the elevators of the jaw and the mylohyoid, by the facial to the digastric and the muscles of the lips and cheek, and by the hypoglossal to the muscles of the tongue.

In considering the mechanism of the process of mastication, it must be remembered that the action of the cheek muscles and tongue in replacing the food between the teeth after each movement of the lower jaw is quite as essential as the jaw movements themselves, since otherwise the jaw movements would be entirely useless. This is demonstrated by the fact that in bilateral paralysis of the tongue, of either sensory or motor type, mastication becomes almost impossible, and also in paralysis of the buccinator muscle, accompanying facial paralysis, the

food accumulates in a pouch on the side of the flaccid buccinator, from which it must be removed from time to time by the pressure of the hand applied to the cheek.

The mechanism of action of the tongue and cheek muscles in mastication is carried out in the following manner: By each chewing action of the lower jaw, whether it be an upward movement closing the jaws or a grinding lateral movement, the food is subjected to pressure by the teeth from above downward and to muscular pressure produced on the inner margin by the tongue and on the outer margin by the buccinators. The jaw pressure is the more powerful of the two, and hence the portions of food lying immediately between the teeth, after being bruised, crushed, or divided, are thrust on each side into the regions of less pressure, that is to say, either between the tongue and palate or into the pouches of the cheeks. Then the lower jaw is dropped, and by the contraction of the buccinators on the one hand, and the pressure of the tongue toward the hard palate on the other, the food is restored again to its position between the teeth, in readiness for the next action of the teeth upon it.

The tongue is moved forward by the genioglossus and its transverse intrinsic fibres, and retracted by the hyo-, palato-, and styloglossi. Lateral movement is aided by contraction of the intrinsic longitudinal fibres.

The movements of the lower jaw may conveniently be described as consisting of two types, although any given movement of mastication usually is a complex of the two types, co-ordinated or combined with each other in varying proportion. Movement at the condyles may either be effected as at a simple hinge joint, giving as a result merely an up-and-down movement of the lower jaw such as occurs in speaking; or the condyles may be moved backward or forward on the interarticular cartilages, so causing a gliding movement of the lower jaw. Moreover, in the second type of movement, the extent of movement may be different at each condyle or even performed in an opposite direction, namely, forward at one condyle and backward at the other, so giving rise not to simple backward or forward gliding movements but to combinations of these with lateral gliding movements. It is this kind of movement by which the grinding action of the molar teeth is brought about, and it is hence seen typically in ruminants; while the simple up-and-down action is seen in the "biting off" action of the incisors, and piercing action of the canines; this is hence the typical action of the carnivorous jaw.

The share taken by the various muscles in bringing about these movements may be apportioned in the following manner; but it must always be remembered that any movement is in most cases a resultant of the action of nearly all these muscles called forth in varying degree, in some cases in the direction of increased tonicity or contraction, and in other cases of diminished tonicity or relaxation: The lower jaw is raised by the action of the temporal, masseter, and internal pterygoid muscles; it is lowered, chiefly passively, by the action of gravity, but this is probably normally aided by the contraction of the anterior belly of the digastric, and in forced depression also by the mylo- and geniohyoid muscles. Forward movements are effected most powerfully by both pterygoids acting in concert, while if these muscles act on one side only, that side is drawn forward round the opposite condyle as an axis, thus causing lateral movement toward the opposite side. The *external* pterygoid possesses only this lateral action, and acting alone can, from the direction of its fibres, neither raise nor lower the jaw; but, as stated above, a certain component of the force of the *internal* pterygoid acts as an elevator of the jaw.

The posterior position of the jaws, in which the lower incisors lie behind the upper, and the condyle of the jaw rests in the glenoid cavity, is the natural one of stable equilibrium toward which it returns on account of the elasticity of its attachments when the pterygoids cease to pull upon it; but the posterior fibres of the temporal and masseter muscles tend to draw it backward. The anterior fibres of the masseters, in addition to their main action of elevating the jaw, have also a small forward component.

Benjamin Moore.

MASTOID OPERATIONS.—INDICATIONS FOR OPENING THE MASTOID CELLS.—There is no single symptom, local or general, which, considered by itself, will lead the surgeon to say positively that the mastoid cells ought to be subjected to a direct investigation. The decision to take this step will have to be reached by a careful consideration not only of the history of the case and of the actual conditions revealed by the ordinary examination of the ear and its surroundings, but also of the kinds of micro-organisms found by the bacteriologist in the discharge that escapes from the middle ear. If the services of the latter were more often called into requisition by the surgeon, to aid him in determining whether or not he should open into the mastoid process, it is highly probable that operative interference would be resorted to earlier and with greater confidence, as well as in a much larger number of instances, than is now the case. In corroboration of this statement I have only to say that the knowledge that the specially virulent streptococcus, and not the staphylococcus or the pneumococcus, is the infective agent, in any given case of suspected mastoid involvement, will remove from the minds of most surgeons any remaining doubts in regard to the wisdom of resorting to an operation. The most constant and the most indicative symptom of the purulent involvement of the mastoid process is a *very profuse and creamy discharge of pus* from the middle ear associated with a *prolapse of the posterior and superior cutaneous wall of the external auditory canal near the drum membrane.* But there may be serious involvement of the mastoid cells even when these associated symptoms are entirely absent. Thus, for example, I have seen at least two cases in each of which the discharge had stopped for a period of between two and three weeks, the perforation had healed, and the drum membrane presented a practically normal appearance; and yet in each of these cases the mastoid portion of the temporal bone was found to be extensively diseased. In one of the patients there was neither pain in the region of the ear nor tenderness on pressure over the mastoid process. Nevertheless, pus had accumulated beneath the mastoid periosteum, the pulse was increased in frequency, and there were occasional elevations of temperature. In the second case referred to above, marked mastoid tenderness was present. An operation was performed in both instances and it was found that in each case the mastoid cells were filled with pus, and that, in addition, large extradural abscesses were present—the abscess, in one case, extending beyond the occipito-mastoid suture.

A very frequent and very prominent symptom is *tenderness on pressure* over a whole or a part of the mastoid process. The tip is the most frequent site of this tenderness and the area over the antrum comes next. When the tenderness is most marked back of the mastoid tip it is very likely that we are dealing with a case of perisinous abscess. Another point where mastoid tenderness is to be detected is upon the posterior surface of the wall of the external auditory canal. If the case is a recent one this tenderness on pressure may not be very significant; but if it persists, especially after the use of the ice coil for thirty-six hours, then it is time for the surgeon to invade the mastoid cells. The difficulty is, that this symptom is frequently absent even in a case of well-marked mastoiditis. A differentiation will have to be made between tenderness on pressure due to mastoiditis and tenderness due to a furunculosis of the external auditory canal. The history of the case will be of service in reaching a conclusion. If mastoiditis is present, there will generally be a history of pain followed by a discharge; the active pain then ceasing. Then besides, as the canal is generally found to be sufficiently open for the observer to obtain a view of the drum membrane, he will be able to see the pus oozing through a perforation. On the other hand, in a case of furunculosis of the external auditory canal the pain does not diminish but rather

increases, the canal is stenosed, there is little or no discharge, and, with the aid of a probe, a localized area of tenderness may be detected at some point on the wall of the external auditory canal.

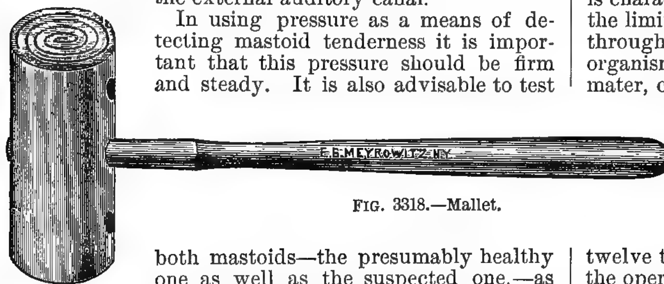

FIG. 3318.—Mallet.

In using pressure as a means of detecting mastoid tenderness it is important that this pressure should be firm and steady. It is also advisable to test both mastoids—the presumably healthy one as well as the suspected one,—as in some individuals hyperæsthesia is marked, and one may find as much tenderness on pressure over the healthy mastoid as over that which appears to be involved.

Pain which is located in the mastoid process or its vicinity, and which persists despite free drainage, is another diagnostic symptom of mastoiditis. Still another is to be found in *hyperæmia and œdema of the skin covering the mastoid process.* When this is found in a case in which furuncular inflammation of the external auditory canal is not present, it is time, in the vast majority of instances, to operate. The only exception is in those cases in which this symptom manifests itself very early in the disease (the second or the third day). As a rule, however, hyperæmia and œdema develop at a relatively late stage of the disease, and when they are present the signification generally is that the case has progressed very rapidly, or that the mastoid cortex is quite thin, or that the operation has been delayed beyond the period of safety. Extension of the inflammation into the soft parts of the neck generally means that a perforation through the inner table has taken place. It may also signify a similar perforation through an unusually thin bony wall of one of the large cells at the tip of the mastoid process.

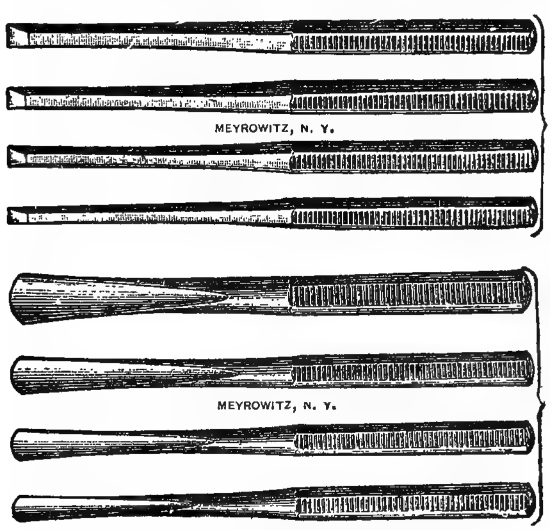

FIG. 3319.—Mastoid Chisels and Gouges.

If the *temperature* remains high or is of a septic type, the operation ought not to be delayed.

Finally, it must be remembered that there are cases of well-marked mastoiditis in which all of the symptoms mentioned above may be absent.

A good rule to follow, in all cases of mastoiditis, is—"when in doubt operate"; never wait for redness and swelling over the mastoid. While the operation is one that requires skill and is not to be lightly undertaken, yet it is also one that if properly performed is practically devoid of danger. On the other hand, the disease itself is characterized by a decided tendency to spread beyond the limits of the mastoid process. It may force its way through the inner table of the skull, and the pyogenic organisms may reach the sigmoid sinus, dura mater, pia mater, cerebrum, or cerebellum, there to set up a septic sinus thrombosis, a pachymeningitis, an extradural abscess, a leptomeningitis, a cerebral or a cerebellar abscess. A disease which carries such deadly possibilities within itself is a disease not to be trifled with.

PREPARATION OF THE PATIENT.—If the exigencies of the situation are such that from twelve to eighteen hours may be allowed to elapse before the operation, the patient should be prepared as for any other major operation. The bowels should be thoroughly evacuated, the healthfulness of heart, lungs, and kidneys ascertained, and the patient should be without any food in the stomach for a period of, at least, six hours before the administration of the anæsthetic.

The hair, for a considerable extent in the vicinity of the mastoid process, should be shaved and the underlying skin surface, as also the auricle, rendered aseptic by cleansing with tincture of green soap and warm water, alcohol, and a 1 to 1,000 bichloride-of-mercury solution, and then covered with a moist bichloride of mercury (1 to 3,000) dressing.

The external auditory canal, which is, as a rule, serving as a drain for the pus flowing from the tympanic cavity, should be irrigated with a bichloride-of-mercury solution (1 to 3,000) sufficiently often, during the interval between the application of the moist dressing and the time of operation, to keep it fairly free of pus. After each irrigation a wick of sterile gauze should be inserted into the canal and a fresh external dressing applied.

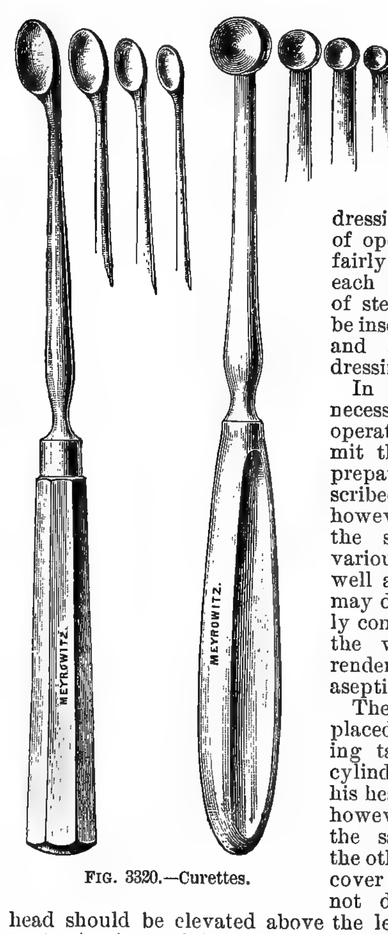

FIG. 3320.—Curettes.

In many cases the necessity for immediate operation will not permit the making of the preparations just described. In all cases, however, the patient, the surgeon, and his various assistants, as well as everything that may directly or indirectly come in contact with the wound, should be rendered as thoroughly aseptic as possible.

The patient should be placed upon the operating table with a hard cylindrical pillow under his head. (This pillow, however, should be of the same thickness as the other cushions which cover the table, as it is not desirable that the head should be elevated above the level of the shoulders.) A piece of india-rubber sheeting, large enough to extend well over the shoulders and chest of the patient and below the cushions of the table, should be

securely fastened about his neck. This sheeting should be covered with towels which have either been wrung out in a bichloride-of-mercury solution or have been subjected to dry sterilization. The unshaved portion of the head should be carefully wrapped in a moist bichloride-of-mercury towel.

It matters not how simple the case of mastoiditis about to be operated upon may appear, the surgeon should at

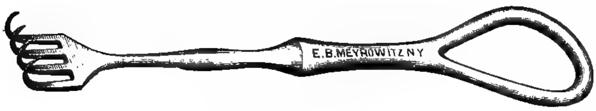

FIG. 3321.—Retractor.

all times be prepared, if such a step should be found necessary, to open the sinus and excise the jugular vein for a sinus thrombosis, or to trephine the skull and explore the brain for a cerebral or a cerebellar abscess. He should have for the operation a scalpel, a rawhide or lead mallet (Fig. 3318), chisels and gouges (Fig. 3319), scissors curved and flat, a periosteal elevator (Fig. 3326), curettes (Fig. 3320), retractors (Fig. 3321), rongeur forceps (Figs. 3322, 3323, 3324, and 3325), artery forceps, dressing forceps, silver probes, aneurism needle, a trephine, an infusion apparatus, an irrigation bottle, needles, catgut for ligatures, silkworm gut for sutures, iodoform gauze in bulk and also in strips one-half inch and one inch wide (Nu gauze, with selvedge edge, as prepared by Johnson & Johnson, has the advantage of not unravelling), dry sterile gauze handkerchiefs and sterile cotton for dressings, bandages two inches wide, also dry sterile gauze sponges.

THE SIMPLE MASTOID OPERATION.

Each surgeon will have his own preferences as to minor operative details. I prefer to stand at the head of the table, near its right-hand or left-hand side, according to whether it is the right or the left ear which is involved. The anæsthetist stands in front of the patient's everted face; the second assistant, who manages the retractors and holds the artery forceps out of the way, stands between the anæsthetist and myself; while the first assistant, who sponges and seizes bleeding vessels, stands on my other side. The instrument table with the attendant nurse is within my convenient reach.

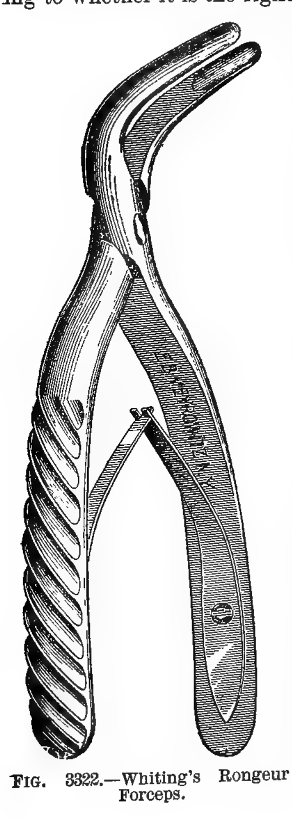

FIG. 3322.—Whiting's Rongeur Forceps.

Narcosis.—My preference is for nitrous oxide gas followed by ether, as used by Dr. Bennett, of this city (see Vol. III., p. 9). In cases of suspected brain abscess in very young children, in kidney complications, or when œdema of the lungs is to be feared, chloroform is to be preferred. Schiebe reports six cases in which local anæsthesia (ethyl chloride) was employed, in five of which cases it gave good satisfaction. Berens, of New York, operated successfully in one case with orthoform anæsthesia.

As a preliminary step to the operation the drum membrane should be incised, if a free opening does not already exist in it, and a strip of iodoform, or of plain sterile gauze, should again be inserted into the auditory canal.

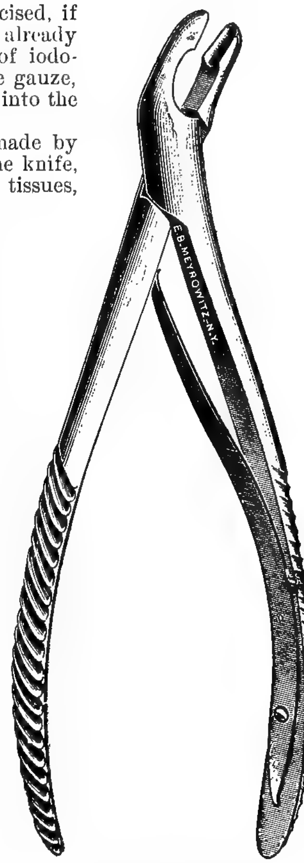

FIG. 3323.—Bacon's Rongeur Forceps.

The first incision is made by inserting the point of the knife, held vertically to the tissues, over the tip of the mastoid process and carrying it through the periosteum to the bone; the handle should then be lowered so that the curved edge of the blade does the cutting; and the incision itself should be carried, in a direction parallel to the insertion of the auricle and about 5 mm. from it, to a point directly above the external auditory canal (see Fig. 3327, *A D B*). In adults the scalpel should cut through the periosteum with the first incision, but in the case of children it is not safe to do this, for the reason that in them the cortex of the mastoid process is so thin that the knife might easily pass through it and so wound the underlying sigmoid sinus or the dura mater. In cases in which the mastoid process is large, it will be necessary to make a second incision (Fig. 3327, *D E*), extending horizontally backward on a level with the external auditory canal and at right angles to the first one. In still another group of cases it may be necessary to extend the first incision horizontally forward (Fig. 3327, *B C*), a short distance in front of the anterior insertion of the auricle.

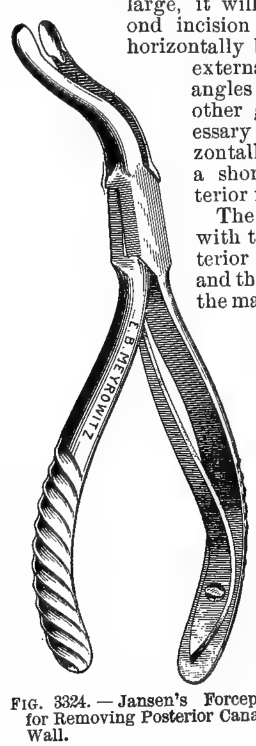

FIG. 3324. — Jansen's Forceps for Removing Posterior Canal Wall.

The next step is to push backward, with the periosteal elevator, the posterior flap including its periosteum, and thus expose the greater portion of the mastoid process. In a similar manner the anterior flap and its periosteum are to be pushed forward for the purpose of exposing the posterior and superior borders of the external auditory canal and the root of the zygomatic process. In separating the periosteum from the bone, great care should be taken to avoid wounding the former.

Our next procedure is to control all bleeding by means of artery forceps. After this has been accomplished a retractor is placed in position so as to hold forward the anterior flap, and another is placed to hold backward the posterior flap. It is gener-

ally necessary at this point in the operation to extend, with the scissors, the first incision downward for about 8 or 10 mm. Then with the blunt-pointed scissors, curved on the flat, we separate the tendinous insertion of the sterno-cleido-mastoid muscle from the tip of the mastoid process. The bony surface of the mastoid process having thus been fully exposed to view, we must take notice of the landmarks which are to guide us in our further operative procedures. First, we notice the posterior and superior margins of the external auditory canal and at their juncture a little fossa, the *supramastoid fossa*, in front of which is to be found a small spine, *spina supra meatum*, or the *spine of Henle*. The supramastoid fossa presents a sieve-like appearance, due to the presence of several vascular foramina—the *vascular zone*, or, as it is called by some authors, the *spongy spot*. At times these vascular foramina dip down into the underlying cells, the lining mucous membrane of which comes almost in contact with the external periosteum, and so renders the passage of pus from these cells to the surface of the mastoid easy. This fossa is situated exactly at the level of the mastoid antrum. From infancy to adult life its position changes. In infancy it is above the meatus, from which point it gradually moves downward and backward in a circle concentric to the auditory meatus until, in adult life, it is to be found immediately behind the suprameatal spine. The centre of the antrum in infancy is slightly above and behind this fossa; it then gradually passes downward and backward until at the age of ten it is directly back of the suprameatal spine, from which point it passes backward until, in the young adult, it reaches a distance of about 7 mm. from it. This fossa is our most important guide to the antrum, as it is always present, whereas this is not true of the suprameatal spine, which changes its position, as does the antrum, from infancy to adult life. Macewen's guide is a triangle, which he terms the "suprameatal triangle," formed above by the posterior root of the zygomatic process, below by the superior and posterior wall of the bony external auditory canal, and behind by an imaginary line connecting the extremities of these two lines.

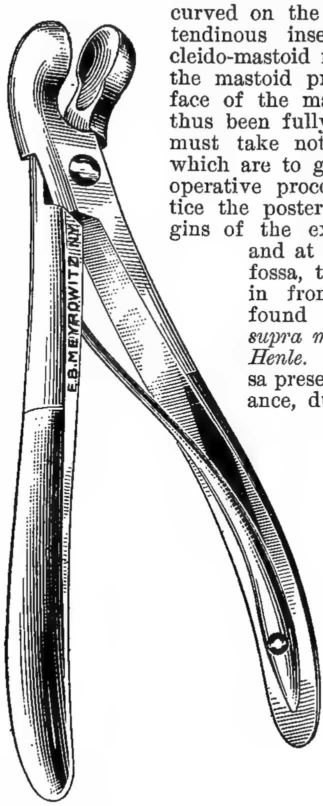

FIG. 3325.—Mathieu's Rongeur Forceps.

FIG. 3326.—Langenbeck's Periosteal Elevator.

In early life the non-existence of the posterior root of the zygomatic process renders this guide less positive than the one mentioned above.

The next landmark to observe is the linea temporalis which is the extension backward of the posterior root of the zygomatic process. This is an important guide, as it fairly accurately indicates the level of the floor of the middle fossa, the latter being more often a little below, instead of a little above, this line. Before beginning the operation it is well to call to mind the anatomical structures which are to be avoided. The floor of the middle cranial fossa is, as I have stated above, fairly easily avoided by not removing any bone above the line of the temporal ridge. Another very important structure which should be borne in mind is the lateral sinus. This structure is very variable in its relation to the mastoid antrum, its position varying, according to Lake (*Journal of Laryngology, Rhinology, and Otology*, vol. xiii., p. 231), from 0.2 inch (5 mm.) to 0.7 inch (about 17 mm.). On an average it is situated at a distance of 0.48 inch (12 mm.) from this cavity. The sinus is more superficially situated than the antrum; on the right side it extends, as a rule, more forward than does that on the left side.

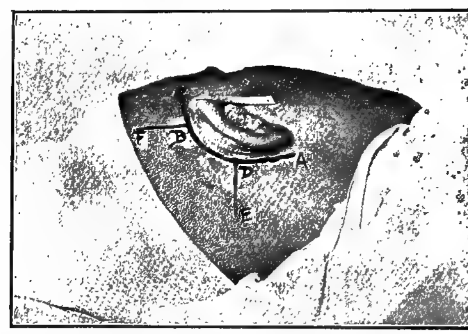

FIG. 3327.—Shows the Patient Prepared for Operation and the Various Incisions. *A D B*, Line of incision close to auricular fold—the only incision necessary in most cases of simple mastoiditis; *D E*, the posterior incision necessary in cases with a large mastoid process, in sigmoid sinus thrombosis and in intracranial complications situated in the posterior fossa; *B C*, extension of first incision necessary in the radical operation, the Stacke operation, and in intracranial complications in the middle fossa; *B F*, additional vertical incision necessary in cases of intracranial complications in the middle fossa. (The strip of adhesive plaster is used merely to hold the auricle forward so as to show the line of incision.)

In infancy the depth of the antrum from the cortex of the mastoid process varies from 2 to 4 mm.; in children it has been found as deep as 11 mm. In adults, on the other hand, it is much farther removed from the surface of the bone. Thus, Broca states that he has found it, in two very old subjects, at the extreme depth of 25 mm. in one case, and 29 mm. in the other. When the surgeon encounters a case in which the antrum is located at an unusual depth, he must persist in his efforts to reach his objective point, but at the same time he must proceed with caution. In pneumatic mastoids this is comparatively an easy thing to do, but in chronic conditions, where sclerosis has taken place and it is necessary to chisel through a hard compact mass of bone, to proceed requires the determination which comes alone from experience and from the knowledge that the antrum does exist and is to be found. The antrum is connected with the tympanic cavity by a canal—the *aditus ad antrum;* this canal is from 3 to 5 mm. long, 3 mm. high, and 3 or 4 mm. deep. Its upper wall, the *tegmen tympani*, forms part of the thin plate which separates the tympanic cavity from the cranial cavity; at times it is wanting. The mucous membrane and endosteum lining the tympanum are in close contact with the underlying bone, and hence in purulent inflammations of the tympanum caries and necrosis readily occur. In view of the fact that the tegmen tympani and the tegmen antri are very thin, or may even be wanting, it is a source of wonder that abscess of the middle or of the posterior portion of the temporo-sphenoidal lobe does not more often occur.

Two very important structures, it must be remembered, are in close relation to the aditus ad antrum,

Mastoid Operations.

namely, the *facial nerve*, and the *horizontal semicircular canal*. The facial nerve is the most important structure to be avoided in all mastoid operations. There are two places in its course where it is most likely to be exposed to injury in operative procedures around the mastoid. The first point is situated in the horizontal portion and elbow of the facial canal, where it passes under the aditus ad antrum. When the nerve is wounded here it is generally due to the careless use of the curette when employed for removing granulations from the epitympanic space. The second point where the nerve is liable to injury is near its exit from the stylo-mastoid foramen. It is apt to become involved at this point in those cases which are spoken of as instances of Bezold's perforation—cases in which perforation of the inner table or anterior surface of the mastoid process takes place. The nerve is also apt to receive damage at this point in infancy, because the undeveloped condition of the mastoid process leaves the stylo-mastoid foramen more exposed upon the lateral surface of the bone than is the case in adult life.

The only part of the internal ear which is apt to be encountered in operative work is the horizontal semicircular canal. This canal, which is surrounded by an eburnated sheet of bone and is situated just behind the inner wall of the aditus ad antrum, is rarely injured. In order to avoid injuring it, one needs only to be careful not to curette the inner wall of the aditus ad antrum.

The short process of the incus is another part which bears some relation to the aditus ad antrum; it rests upon the floor of this canal at its tympanic end.

The surgeon having recalled to memory the various landmarks and the relations between the structures which he expects to invade and those which he must avoid, is now ready to proceed with the bone operation. As the first step, he should remove, with the chisel, a square of bone, the sides of which should each measure about 7 or 8 mm. in length. The anterior superior angle of the shallow excavation (2 or 3 mm. in depth) thus made should include the suprameatal fossa. When in use the chisel should be held at an acute angle to the bone surface and it should be so firmly grasped that, should the cortex of the bone prove thin, the chisel will not plunge too deeply into the underlying structures. If the mastoid is of the pneumatic type, the removal of this square of bone will probably bring into view its cellular structure. As soon as this has been effected, I prefer, as the next step,—instead of continuing to work a passage down into the antrum,—to remove the cortex along the anterior border of the mastoid process as far down as its tip. From the vertical groove thus established I proceed, with chisel and rongeur forceps (chiefly the latter), to remove the remaining cortex of the mastoid process. The chisel is then set aside, and, with curette and forceps, I remove each dividing cell wall of the whole mastoid structure until the cells are entirely obliterated and the inner plate of the mastoid process is reached. This thin plate of bone, as will be remembered, is the only structure which separates the sinus and the dura of the posterior and middle cerebral fossæ from the pit made by the removal of the mastoid cells. If, upon careful examination, it shows evidences of being diseased, or if, though it should appear to be healthy, the history of the case should warrant the suspicion that pathological conditions exist in either of these fossæ, or that the lateral sinus is involved, this plate of bone must be removed to permit of a thorough examination.

If it should appear to some that the plan here advocated, of removing all the mastoid cells, is unnecessarily thorough, I will call their attention to the fact that unless these structures are completely eradicated, some remote cell with its nidus of infection may be left behind, and then, weeks later, when the wound is still open, although apparently well on its way toward healing, we are forced to conclude, from the unsatisfactory manner in which the case is progressing, that we did not do our work thoroughly, and that the operation, with all its attendant dangers and worries, must be performed a second time. It is surprising to note how often, in the course of a mastoid operation, one encounters—at some point quite remote from the antrum and separated from it by other cells which to the unaided eye appear to be fairly normal, or at all events free from the presence of anything like purulent material—a single cell filled with pus. Such a discovery is apt to be made among the cells situated in the posterior portion of the tip of the mastoid process, and occasionally also among those located in its upper and posterior portion.

As even the complete destruction of the distinctive mastoid (*i.e.*, pneumatic) cells cannot be trusted to eradicate all the sources of infection, it is advisable, in addition, to obliterate all the cellular structure located above the external auditory canal and at the root of the zygomatic process, as well as that which lies partly between the antrum and the knee of the lateral sinus, and partly at a still greater depth (*i.e.*, nearer the centre of the skull).

Finally, it will generally be found best to remove the entire tip of the mastoid process, instead of leaving, as is often done, its inner surface, which serves no useful purpose. In course of time the sterno-cleido-mastoid muscle forms new attachments, and I have never seen a case in which the muscular movements of the head were at all interfered with as the result of the removal of this plate.

In carrying out the operation in the manner here described, the surgeon will always have before him a broad and open field in which there are no obscure pockets. If he chance to wound the sinus—an accident which is generally the result of undue haste—he will experience no difficulty in controlling the hemorrhage by the simple application of an iodoform gauze tampon; and afterward he may proceed with the operation by working around this tampon—a procedure which could not so readily be carried out if the sinus had been wounded while he was working at the bottom of a deep cavity.

It is important to use the probe freely, as the operation proceeds, so as to ascertain whether or not the granulations are lining a bony cavity or are springing from the dura mater or sinus and protruding into the mastoid cells through an opening in the inner table. Unless this precaution is taken, it is easy, while using the curette, to wound the exposed dura mater or to plunge into the sinus. The probe should also be used for the purpose of searching most carefully for the existence of any possible sinus, which may lead through the inner table into either the middle or the posterior fossa. If such a sinus is found to exist, it should be enlarged sufficiently to permit of the easy examination of the underlying tissues. This careful investigation is absolutely necessary, for it is by means of such a thorough probing that many a case of unsuspected perisinous abscess, or of extradural abscess, has been discovered.

In cases of perforation through the posterior wall of the external auditory canal this bony partition will have to be removed to a limited extent and the adjacent soft tissues carefully curetted. It is rarely necessary, in acute cases, to remove that portion of the posterior wall which includes the tympanic ring.

If the mastoid process is one that contains few pneumatic cells, the surgeon, in performing the operation, must adopt a course somewhat different from that which I have advocated above; he must first search for and find the antrum, and then from this point he should work toward the tip and posterior portion of the mastoid process until this process has been fully excavated. Such thorough excavation is as necessary in these cases of sclerosis as it is in those first described, for in this type of mastoid a large cell is often found remotely situated from the antrum, and yet filled with pus. In fact, I have operated upon cases in which, while the antrum and adjacent cells were apparently free from purulent matter, a cell located posteriorly and near the tip has been found to be full of pus.

In cases in which a perforation has already taken place spontaneously in the cortex of the mastoid, the use of the chisel is unnecessary; the surgeon may begin at once with

the curette and follow the fistulous tract which exists and which always leads into the antrum. After he has reached this cavity he may proceed with curettes and forceps as in the first type of cases. In following such a fistulous tract, however, considerable caution is needed if one wishes to avoid plunging into an uncovered lateral sinus.

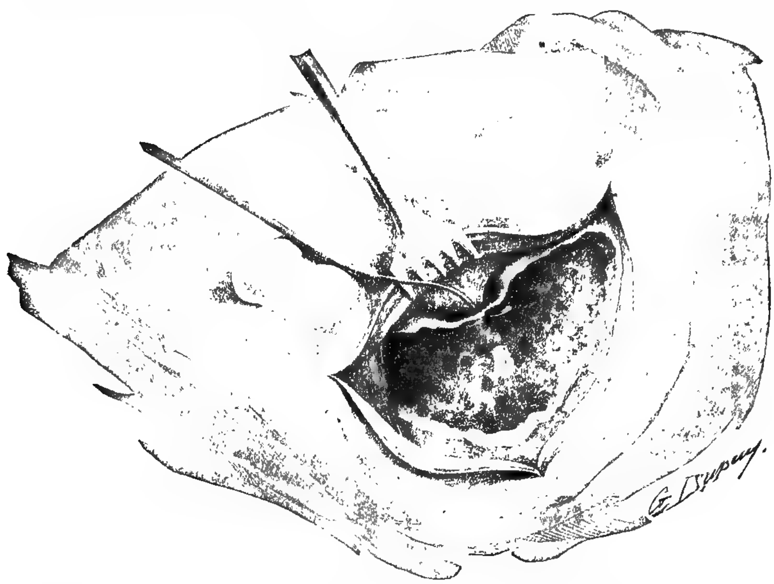

FIG. 3328.—The Completed Operation for Simple Mastoiditis. The digastric muscle is shown, at the inferior portion of the field of operation, occupying the place previously occupied by the removed mastoid tip. The upper portion of the operative field shows the ablation of the cells at the root of the zygomatic process. These cells at times extend farther forward than is shown in the illustration. The illustration is also utilized to show the placing of the bent silver probe in position, which acts as a guide in the removal of the posterior wall as is done in the radical operation (see below). The probe is introduced between the bony and membranous walls of the external auditory canal into the middle ear through the aditus and antrum and its bulbous-tipped end shows in the excavated antrum. Of course this probe is not used in cases of simple mastoiditis. In an illustration of this character it is impossible distinctly to show the actual depth of the antrum and the excavated portion of the mastoid process.

When the surgeon is positive that every pneumatic cell of the mastoid process has been excavated, and after he has carefully smoothed down all the rough places both on the inner table of the mastoid process and along the edges of the excavation in the bone, he may either cleanse the cavity with a decinormal salt solution or simply mop the surface with dry sterile gauze. (In children particular care should be taken not to use such solutions as one of bichloride of mercury, on account of the ease with which solutions pass through the Eustachian tube into the throat.) After this has been accomplished, the next step is to tie off any bleeding vessels, then to close with silkworm-gut sutures the posterior cutaneous incision, if one has been made, and, finally, to close in the same manner the upper angle of the auricular incision as far as the level of the external auditory canal. The remainder of the incision is left open. The cavity of the wound is packed with iodoform gauze, and a small wick of iodoform gauze is also inserted into the external meatus. The wound and the auricle are then covered with sterile gauze and a bandage is applied over all.

This dressing is left in place until the sixth or seventh day (unless pain, or a rise of temperature, indicates the necessity for its earlier removal). In many cases a post-operative fever will occur on the day after the operation, and in infants and young children the temperature is very likely to rise as high as 102° F. If the fever continues on the second and third days it may be due to wound infection or to some complication; under these circumstances the dressings should be removed and the parts examined. The cavity at each dressing is dry-cleansed, a sterile gauze dressing is very loosely placed in it, and the external dressings are applied as before. The sutures are removed on the seventh or eighth day. If the case has been one of simple mastoiditis, it is seldom requisite to keep the patient in bed more than from seven to ten days. Care must be taken in all subsequent dressings that the granulations shall spring up evenly around the bottom of the wound, and that the superficial healing of the would shall not occur before the cavity is filled with healthy granulation tissue.

In cases with a past history that is favorable, healing takes place in from four to six weeks; while in cases with a previous history of ill-health the healing may be delayed for as many months. The after-care of the case is one that requires much judgment. Irrigation, especially with a solution of bichloride of mercury, is injurious to the delicate granulations which are endeavoring to fill the cavity. For cleansing the latter, careful use should be made of pledgets of dry gauze or of pledgets of absorbent cotton moistened in sterile water. After the first few dressings the wound should be packed with simple sterile rather than with iodoform gauze, as the latter tends to promote exuberant granulations. The packing should be introduced somewhat loosely, the quantity of gauze used being simply sufficient to absorb the discharge and to prevent the superficial union of the tissues. The scissors or the curette or the stick of pure nitrate of silver or chromic acid may be used for the removal of exuberant granulations, which at times form along the edges of the wound. To stimulate the formation of granulations on the bone, in cases which are slow to heal, an application of pure carbolic acid, followed immediately by one of absolute alcohol, will be found advantageous. A solution of nitrate of silver, of a strength of from forty to sixty grains to the ounce of distilled water, or balsam of Peru, may also be used. Insufflations of boric acid, of subgallate of bismuth, or of xeroform, are of assistance in cases in which there is much discharge, as also toward the end of the healing process. After the first few dressings the gauze bandage (Johnson and Johnson manufacture a black gauze bandage which is less conspicuous than the white one) may give way to a black silk pad which is tied over the wound by means of tapes passed around the head. When the wound becomes small enough, the dressing may be fastened to the skin by means of flexible collodion.

THE RADICAL OPERATION, OR THE SCHWARTZE-STACKE OPERATION.

This operation is undertaken for the purpose of curing cases of chronic purulent inflammation of the middle ear in which the actual disease is not confined to the lower portion of the tympanic cavity and the cells around the tympanic end of the Eustachian tube, but consists of a caries of one or more of the ossicles and of some portion of the epitympanic space, associated with caries of the adjacent cells. The disease may or may not be accompanied by a cholesteatomatous condition of these cavities.

By means of the operation the surgeon seeks to establish a single large cavity consisting of the excavated mastoid cells, the tympanic cavity, and the external audi-

tory canal; this cavity eventually to be lined with a non-secreting epidermal membrane.

Indications for the Operation.—In all cases in which there is a chronic purulent discharge (odorless or non-odorless), which will not, after a thorough trial, yield to skilled treatment, this operation ought to be performed, and no other objective symptom is to be waited for. And why? Chronic purulent inflammation of the middle ear is the direct cause of from thirty (Pitt) to fifty (Barr) per cent. of the brain abscesses that occur. It is estimated that in this country about four thousand cases of brain abscesses of otitic origin end in death annually. According to Körner the Prussian statistics for 1885 give a death rate for otitic brain abscess three times as great as this for each ten thousand of population, or 1.5 for each ten thousand of population. A fairly large percentage* of the cases of leptomeningitis, of pachymeningitis, of pyæmic sinus-thrombosis, and, to a less degree, of septic pneumonia, pleurisies, etc., are of otitic origin. To prevent the development of these most serious complications the aural surgeon must urge the necessity of dealing with every case of chronic purulent discharge from the middle ear as something not to be lightly regarded, but as a disease which must be eradicated, no matter how innocent a case it apparently may be. The disease is capable of advancing most insidiously, and generally without any symptoms, until a very extensive destruction not alone of the tympanic cavity and its adnexa but of the brain tissues as well, has taken place. Brain abscesses have often been found at the autopsy to have been the cause of death when no such lesion was suspected in life. How many more cases of this and other pyæmic complications of otitic disease are fatal annually, in which death is attributed to the complicating pyæmic metastasis, or to apoplexy, or to heart disease, may only be suspected.

Macewen says "that one who has a chronic purulent otitis media is liable to have, with very little warning, a most serious or even a fatal illness." Acute or chronic disease of the middle ear is a disease that is fraught with much danger to life and should always be regarded most seriously.

THE STEPS OF THE OPERATION.—The first portion of this operation is performed, with some slight changes, in the same manner as is the operation for simple mastoiditis. The incision is carried a little farther forward to a point a few millimetres in front of the anterior insertion of the auricle. If a fistulous tract exists in the skin surface it is excised or the incision is made so as to include it. In the retraction of the anterior flap it is pushed farther forward and at the same time the posterior wall of the membranous external auditory canal is separated from its bony support and made to lie flat on the anterior wall of the canal, thus exposing the entire upper and posterior wall of the bony canal as far as the tympanic ring. The operation upon the bone is performed in the same manner as in the first operation described, up to the stage at which the latter is considered complete; then from this point onward certain additional steps are required. The first of these consists in bending the tip of a pure silver probe at nearly a right angle (the bent portion measuring about 6 or 7 mm. in length) and then passing it along the posterior wall of the external auditory canal into the tympanic cavity until its tip projects into the antrum (see Fig. 3328). This probe serves as a guide to show the position of the facial nerve, while the upper and posterior canal wall is being removed. Jansen's forceps (Fig. 3324) is the best instrument with which to accomplish this object, although the mallet and chisel may be used in the removal of the external portion of this canal. When, however, the surgeon reaches the internal portion of this posterior wall he will have to remove a bridge of bone which has no support, and if, for the accomplishment of this, he employs the chisel, it may easily happen that he will remove a piece which is much larger than he intended to remove, and which may include the facial canal. On the other hand, with Jansen's forceps, especially curved for this purpose, the amount of bone removed may be accurately gauged. The portion of bone which must be removed at this point extends, like a partition, from the tympanic roof to the floor of the aditus ad antrum. The next step is to remove the remnants of the ossicles and such granulation tissue as may be present in the tympanic cavity, especially in the vicinity of the pharyngeal end of the Eustachian tube and on the floor of the cavity. This is best accomplished with the curette, which must be cautiously used, as it is with this instrument that damage to the facial nerve is most often done. It is therefore safer, before curetting, to use the probe, in order to determine whether or not the facial nerve is exposed. When it is exposed, the pressure of the probe will cause the muscles of the face to twitch. It is by the use of the probe, furthermore, that information is to be obtained in regard to the possible existence of a sinus leading into the posterior or the middle cranial fossa. If such a sinus is discovered the bony structure through which it passes must all be removed and the underlying dura mater and sigmoid sinus inspected, so

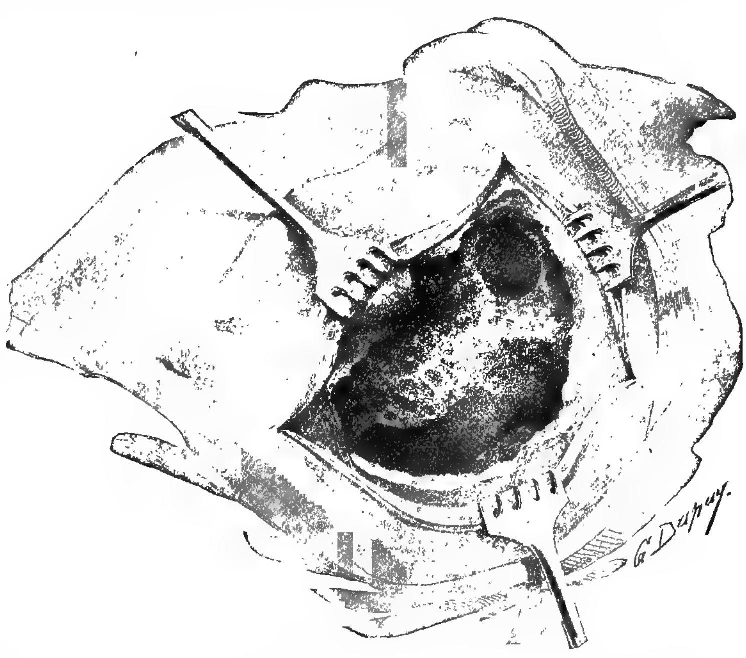

FIG. 3329.—The Illustration Shows the Completed Radical Operation; the Posterior Wall has been Removed, and the Excavated Mastoid Cells and Middle Ear have been United with the External Auditory Canal to Form One Large Cavity. It also shows the exposure of the dura mater in the midde fossa and the exposure of the sigmoid sinus from its knee to within a short distance of the jugular bulb. When it appears desirable to expose the posterior fossa the bone must be removed in a backward direction over a still larger area.

* About five per cent. of all cases of meningitis and two-thirds of all cases of sinus-phlebitis are of otitic origin (Pitt). In 17,028 autopsies in London death was due in 102, or 1 in 167, to an otitic lesion. In 10,707 cases with tympanic suppuration 69 deaths occurred as the result of the aural lesion, or 1 in 155 (Körner). In 38,017 aural patients death occurred, as the result of the disease, in 119, or 1 in 319 (Bürkner's and Randall's individual statistics combined).

that, if any complicating lesion of the meninges, the sinus, or the brain itself, exist, it shall not escape discovery.

In cases of chronic suppuration with cholesteatoma the bone should be thoroughly searched for the presence of any fistulous tract, and if one is found it should be thoroughly curetted. At no point should any but healthy bone denuded of membrane be left behind. Unless this is done a recurrence of the cholesteatoma is most likely to ensue.

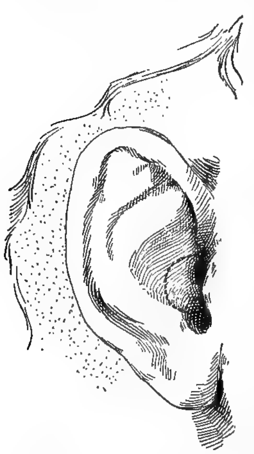

FIG. 3330. — The Incision to Form the Concho-meatal Flap in Ballance's Modification of the Radical Operation.

When the surgeon has smoothed and rounded off all sharp edges of bone and is positive that he has removed all necrotic tissue, he may proceed to form, from the posterior portion of the membranous external auditory canal, the flaps which are to serve in large part as a lining membrane for the excavation in the bone. It is usual, at this point, to speak of dividing transversely the membranous external auditory canal near its inner extremity. I may state, however, that I have never seen a case in which the separation of the membranous lining of the canal from its bony support, which is done at an earlier stage of the operation, did not leave free its inner extremity and so render the making of this transverse incision unnecessary. So far as the flaps themselves are concerned, it is possible to solve this part of the problem in four different ways. According to the first method a pair of artery or dressing forceps is introduced into the external auditory canal and held open so as to render tense its posterior cutaneous wall; then, with a small scalpel, an incision is made in the membranous canal through the middle of its superior surface and extending from its freed extremity to the cavum conchæ. A similar and parallel incision is next made through the inferior surface of the canal. In this way (Körner's method) there is formed, out of the posterior canal wall, a quadrilateral flap which is united to the auricle by a vertical line of union in the cavum conchæ. This flap is made thinner, at its outer end, by removing some of the cartilage which enters into its composition. After it has thus been reduced in thickness the flap is turned backward into the mastoid wound and united—by means of two catgut ligatures passed through its free extremity—to the posterior flap of the mastoid incision. The next step is to unite the edges of the mastoid incision—not throughout its entire length, but from the upper end down to within 10 or 12 mm. of its lowest point. The cavity made by these operative procedures and partially lined by the flap described above, is packed through the external meatus with a strip of iodoform gauze, and a small piece is introduced into the lower angle of the mastoid wound. The usual outside dressings are applied.

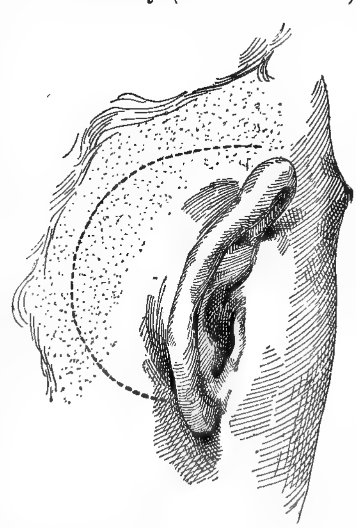

FIG. 3331.—The Incision as Suggested by Ballance in his Modification of the Mastoid Operation.

If the method of operating here advocated is adopted, the raw surface of the flap will be brought in contact with the raw surface of the flaps of the mastoid incision, and subsequently they will unite. From the free edges of this inner flap a new growth of epithelium will gradually extend over the granulating surface of the rest of the cavity, and thus, in the course of time, a non-secreting dermal lining will be supplied for the entire cavity which has been created by the breaking down of the partitions separating the mastoid cells, middle ear, and external auditory canal. After the healing is complete, a survey of the cavity will reveal the fact that a small ridge is located in its lower portion. This ridge, which is composed of the remainder of the posterior bony wall of the auditory canal, contains the facial nerve and divides the cavity into a posterior and an anterior half. In a few instances I have observed the development of facial paralysis at the end of a few hours, or even a day or two, after the operation. I have attributed the phenomenon, which was only transient in character, to the pressure exerted upon an exposed facial nerve by the saturated dressings which filled the cavity.

The second method of providing a lining for the excavation in the bone is that suggested by Panse. The first step in this procedure consists in carrying the incision through the middle of the posterior membranous wall of the external auditory canal as far outward as the cavum conchæ. From this point one incision is carried upward, at right angles to the first incision, as far as to the summit of the superior wall of the canal, while a second one is carried downward as far as the lowest point of the inferior wall; and as a result of these incisions there will be formed two flaps—an upper and a lower one. Each of these two flaps is held in position against the underlying raw surfaces by means of a gauze tampon.

The third method is that suggested by Stacke. According to his plan, the flap is made by carrying an incision through the middle of the superior wall of the auditory canal as far outward as to the cavum conchæ, while from the termination of this first incision a second one is carried downward as far as to the lowest point of the inferior wall of the canal. The flap thus formed is pushed downward into the bony cavity and held in place by a gauze tampon.

In the fourth method the flap is constructed by making the incision through the inferior cutaneous wall instead of the superior, and then by means of the packing it is crowded against the upper and posterior wall of the cavity rather than against the lower and posterior, as in the preceding method.

Ballance has still further modified the operation by adopting the following course: He begins the cutaneous incision over the tip of the mastoid process, but does not follow the auricular groove; instead, he carries the incision at first upward and backward, in a curving direction, and then forward, above the auricle, to a point a few millimetres in front of the anterior superior insertion of the latter. In this way he makes an unusually large semicircular anterior flap (Fig. 3331). From this preliminary incision onward the operation proceeds as in the one described above until the stage is reached at which it becomes necessary to make the flap in the auditory canal In constructing this, Ballance carries his incision along the floor of the canal as far as to the concha, then downward, then slightly backward and upward, and finally slightly forward and upward until the helix is reached (Fig. 3330). This flap is united by sutures to the anterior mastoid flap. After the ends of the suture have been brought through the canal flap the needle is threaded double and passed through the mastoid flap (Fig. 3332), and then the two ends of the suture are tied over a small piece of rubber tubing. The outside wound is entirely closed. The inner cavity is packed with gauze. From ten to fourteen days later

the patient is given an anæsthetic, the cavity is washed out with a warm sterile saline solution, and the mastoid wound reopened. After all oozing has been stopped a Thiersch's skin graft, which has been obtained in the mean time from another portion of the body, and which is large enough to cover completely the granulating surface of the cavity, is carefully applied to this area and then covered with gold leaf. The cavity finally is plugged with sterile gauze which is left in place for two or three days. At the end of this period the gauze should be removed and the gold leaf gently washed out. Ballance claims for this mode of operating a much shorter period of after-treatment.

In the class of cases which we are now considering, the after-treatment requires much judgment. Irrigation should not be resorted to if it can be avoided; as a substitute, very gentle dry cleansing is to be preferred. The first dressing need not be disturbed for six or seven days unless the temperature denotes a septic disturbance; subsequently, however, the parts will have to be dressed every other day. The sutures are generally removed at the time of the first dressing. The gauze drain in the lower end of the mastoid wound is to be gradually shortened until the wound has healed from the bottom. Exuberant granulations are to be cut down by means of the curette, which must be used very gently, or by means of a small bead of nitrate of silver fused on the end of a silver probe. At each dressing the cavity should be dusted with finely powdered boracic acid or with subgallate of bismuth, and a loose packing of sterile gauze should be inserted. If there is much suppuration from the Eustachian tube an application of a solution of nitrate of silver (fifteen or twenty grains to the ounce of distilled water), or of one of sulphate of zinc (five or six grains to the ounce of distilled water), should be made to the mouth of the tube on a cotton-tipped applicator. The cavity must not be allowed to become obliterated by excessive granulations and strict asepsis must be employed so as to prevent the possibility of perichondritis. If the case is one in which an acute exacerbation has taken place, with the formation of a subperiosteal abscess and perforation through the skin, it may be impossible to obtain, from the immediate vicinity, enough healthy skin to cover the exposed portions of the mastoid. When this is found to be the case, the difficulty may be overcome by a resort, at some later date, to a plastic operation, or the healing may be hastened by the transplantation of small skin grafts.

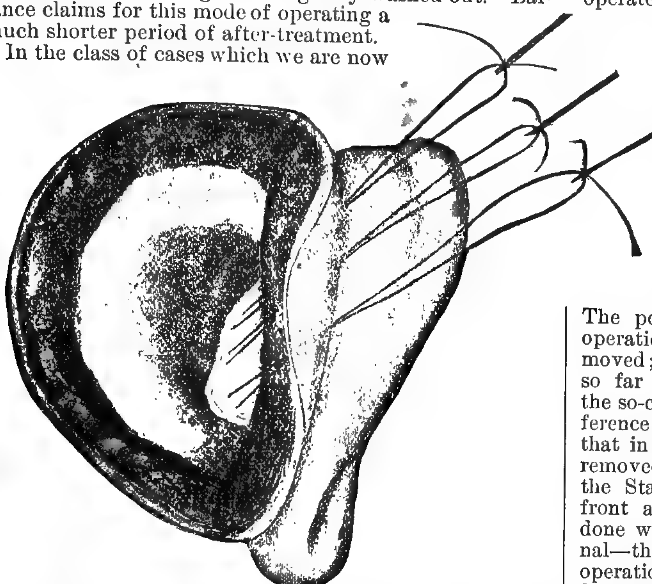

FIG. 3332.—The Concho-meatal Flap is seen Behind the Mastoid Flap. The sutures are passed through it and the two ends of each suture are then threaded on one needle and passed through the mastoid flap and then tied over a piece of rubber tubing. (From Jacobson and Steward: "The Operations of Surgery.")

The Stacke Operation.

The patient is prepared as for the former operations. The first incision is made as in the radical operation described above. The anterior flap is reflected forward so as fully to expose the bony external auditory canal; the membranous canal is then completely shelled out of its bony support and the entire mass is held forward with a blunt retractor. This gives an unobstructed view of the tympanic cavity and of the bony structures to be operated upon. If any remnants of the tympanic membrane or of the ossicles, or any granulation tissue, be present, they should all be removed and the tympanic cavity cleaned. As the next step, the upper and posterior walls of the canal should be removed with the chisel to such an extent as will fully expose to view the epitympanic space and the antrum. Of course great care must be used to avoid wounding the facial nerve. As an extra precaution against this accident Stacke makes use of a hook-like instrument which he calls a "protector" and which is introduced from the tympanic cavity into the antrum, so that if by any chance the chisel should slip it will strike this protector. The posterior canal wall is removed as in the radical operation and all cells adjacent to the antrum are removed; in fact, the operation on the bony parts should, so far as circumstances will permit, be as radical as the so-called radical operation. The chief point of difference between the two is to be found in the fact that in the radical operation the mastoid cortex is first removed and the antrum entered from behind, while in the Stacke operation the antrum is entered from in front and the mastoid cells are excavated by work done wholly from the side of the external auditory canal—the mastoid cortex being left undisturbed. This operation must necessarily be less complete than the Schwartze-Stacke operation, for it is not possible, by way of the external auditory canal, to remove the mastoid cells at the tip, or even those situated at a higher level. Exposure of the middle or the posterior cerebral fossa often takes place in the Stacke as in the other operations, but under strict asepsis this occurrence need cause no anxiety. Stacke's, as well as the other methods of furnishing an epidermal lining for the excavation by means of a flap, has already been described above. The flap or flaps thus provided are to be pushed into place and iodoform gauze packed down upon them to hold them in apposition with the bony wall after the external mastoid wound has been entirely closed. In the subsequent management of the case the same directions are to be followed as those which are mentioned in the description of the Schwartze-Stacke operation.

Operations for Meningitis, Extradural Abscess, Encephalic Abscess, and for Sinus-Thrombosis of Otitic Origin.

Several of these intracranial lesions are often to be found in the same case, the most frequent being an extradural abscess, which is a localized pachymeningitis, walled off by adhesions from the rest of the dura mater. In cases of sinus thrombosis a complicating encephalic abscess is more apt to be cerebellar than cerebral. As a rule, the intracranial lesion is most often found in the vicinity of the most necrotic portion of the causal focus of ear disease.

I. *Extradural and Encephalic Abscesses.*—Extradural abscesses in the middle fossa generally lie just outside of (*i.e.*, below) that portion of the dura which covers the lower and posterior portion of the temporo-sphenoidal lobe, while those occurring in the posterior fossa are in contact with that portion of the dura which encases the anterior portion of the occipital lobe. Of encephalic abscesses the majority are to be found in the cerebrum, and of these the larger proportion are to be found in the temporo-sphenoidal lobe where they generally occupy

the inferior and posterior portion of this lobe, above and behind the tympanic roof and the petrous portion of the temporal bone. In cases of cerebellar abscess the most usual site is at a point close to the anterior and lateral surface of the cerebellum, behind the petrous portion of the temporal bone.

In cases in which the surgeon, although convinced that an abscess exists in some part of the encephalon, is nevertheless unable to decide whether it is located in the cerebrum or in the cerebellum, it is his duty to explore first the most likely sites in the cerebrum, and then, if he fails to find the abscess in this part of the brain, to explore the cerebellum.

Meningitis of otitic origin is sometimes non-suppurative (meningitis serosa). Usually, however, it is purulent in character and limited to a comparatively small area by a preceding adhesive inflammation. In these cases of serous meningitis the early recognition of the presence of the disease and the drainage of the affected region—by the establishment of an opening in the bony wall of the cranial cavity, by incising the dura, and finally by inserting a gauze drain—has in some few cases been the means of saving a patient's life. As a preliminary to these steps one may, according to the acuteness or the chronicity of the causal ear disease, either make a simple opening into the mastoid cells, in order to reach the deeper-lying structures, or perform the radical operation. The tympanic roof must be removed and the dura incised. In cases of meningitis serosa, the ventricle should also be drained, by means of a tent or drain left *in situ*, and in addition it may be well to make a lumbar puncture.

In all cases of intracranial complications of otitic origin, the mastoid cells and the antrum—and, in chronic cases, the tympanic cavity as well—are first to be opened into. Then the surgeon, bearing in mind that in the large majority of instances the intracranial complication lies nearest the focus of infection in the ear, and realizing also that it is desirable to enter the cranial cavity by that route which is at once the easiest and nearest as well as the one which admits of the best drainage, proceeds—in the case of a lesion which he believes to be located in the middle fossa or vicinity—to remove the thin plate of bone which separates the tympanum, antrum, and adjacent cells from the cranial cavity (see Fig. 3329). One surface of this plate of bone—it should be remembered—forms the tympanic roof, the other the floor of the middle fossa. The first opening through the bone is to be made with the chisel, but afterward the curette and rongeur forceps are to be employed for the purpose of enlarging it. Either of these instruments is much to be preferred to the chisel, the trephine, or the dental burr. They are not only fully as effective as these, but they possess in addition the great advantage of not being likely, as are the other instruments, which have to work from without inward, of wounding the deeper-lying soft structures. In the removal of bone by means of the curette or the rongeur forceps the tip of the former or the beak of the latter is inserted between the dura and the bone, and a portion of the latter of the size desired is then easily broken or bitten off; the force applied always working in the direction away from the soft parts. If the cortex is unusually thick and sclerosed at any one point it may be best to employ the chisel for the purpose of removing the more superficial portions, and thus gradually to reduce the bone to the desired degree of thinness. It is surprising, however, how thick a mass of bone the forceps shown in Fig. 3325 is capable of biting off. After the tympanic roof has been removed it is easy to extend the opening in any given direction—as may be indicated by the route taken by the infection—by removing the lateral wall of the middle fossa (the squamous plate of the temporal bone). In removing this plate care must be taken to avoid the middle meningeal artery, as the wounding of this vessel is likely to cause a hemorrhage which it is difficult to control. As has been said above, the larger number of intracranial complications are seated in the lower and posterior portion of the temporal lobe, and consequently, as soon as the plate of bone above the excavated mastoid cells has been removed, it is most likely that the nature of the lesion will then be revealed. Furthermore, the affected area will by this mode of procedure be exposed at its most dependent point. When once the diseased tissues are exposed, bone must be removed until normal tissue shows around the diseased area. If a localized pachymeningitis (an extradural abscess) is present, the simple laying bare of the site of the disease and establishing good drainage, after carefully cleansing the parts, will result in a cure. It is best not to curette any granulations that may be present. If, after they have thus been exposed, they do not soon disappear, cauterization by means of the nitrate-of-silver stick may be resorted to. The wound should be left widely open and antiseptic or sterilized dressings applied.

When an encephalic abscess is suspected but not located, the best way of searching for it is first to incise the dura in the centre of the bone opening so that hemorrhage from any bleeding vessels may be readily controlled. (The reason why the bleeding may more easily be controlled at this part of the wound becomes apparent if we consider the fact that these vessels have a tendency to retract, and if the opening is made near the bony edge the vessels may retract under this bone and so make it difficult for the surgeon to seize them with the artery clamp.) In incising the dura, merely the outer layer should be opened with a knife and the inner layers penetrated with a blunt-pointed, deeply grooved director. The same instrument should be used in exploring the cerebral tissues for the purpose of locating the pus; a trocar and cannula do not answer equally well, as the latter readily becomes clogged, and, besides, it is easily possible to pass the two instruments directly through a pus cavity into sound brain tissue beyond and thus fail to obtain any pus when the suction syringe is applied to the cannula after the withdrawal of the trocar. But when a grooved director is employed in exploring the brain, especially if a little downward pressure is exerted upon the brain tissue at the same time, and if the outer part of the sinus is stretched open by means of an artery clamp or a pair of dressing forceps, the pus—if any has been encountered in the track of the instrument—will almost surely escape by way of the groove in the director. When the brain is exposed in the manner described care must be exercised to prevent the director from penetrating to a vertical depth of more than 3 cm. It may be necessary to introduce the instrument several times before the abscess is located. It should first be introduced in a direction upward, inward, and backward, in the temporo-sphenoidal lobe; then, if the abscess is not found in this direction, the director may next be passed directly inward and upward. If here too no pus should be discovered, it will be well to introduce the director inward, upward, and forward. As regards the proper mode of conducting the exploration I will simply add that the director should be advanced slowly for a short distance and then withdrawn for a part of this distance; then it should be pushed in a second time to a still greater depth and again withdrawn as in the first instance; and so on. When the pus is encountered, the track made by the director should be freely enlarged with the scalpel, and the pus allowed to flow out. The finger should then be introduced to explore the wall of the cavity and the latter should be cleansed with gauze wipes. I prefer this procedure to even gentle syringing with a saline solution and the employment of the double catheter; it is less likely, as it seems to me, to force the pus into the loose open cerebral structures. I also prefer to rely upon a gauze drain rather than upon a rubber or bone drainage tube; for these tubes, as it seems to me, are more unyielding and therefore more irritating to the soft cerebral tissues. A wick formed of a number of strands of catgut or silkworm gut make a good drain. In the subsequent care of the wound it will be found advisable to dry out the cavity in the brain every other day, and sometimes even daily, and on each occasion a shorter drain should be inserted, until the cavity finally

closes. When, as occasionally happens, a hernia cerebri develops after the evacuation of the abscess, moderate pressure and the cicatrization of the tissues will have to be depended upon for the reduction and eventual obliteration of the protruding mass. Celluloid and other materials have been employed to take the place of the loss of bone substance. I have had no personal experience with their use, and am therefore unable to pass judgment upon their value.

When the lesion exists in the posterior fossa or in the cerebellum, the sinus is first uncovered (see Fig. 3329) and the bone gradually removed backward and upward throughout the entire area invaded by the infection. Such removal of bone should not stop until normal tissues appear on every side of the bone opening. It is easy to explore the cerebellum posteriorly to the sinus, the point of entrance being in the angle formed by the junction of the horizontal portion of the lateral sinus with its sigmoid portion. The exploring director is introduced at first inward and forward toward the petrous portion of the temporal bone. If pus is not found here, the director, in the subsequent explorations, should be turned more and more in a backward direction. It is a much more delicate task to enter the cerebellum anteriorly to the sinus. If the director is introduced at this point, it should be kept on a level with the aditus ad antrum, and the surgeon should be cautious about pushing the instrument in a downward direction in the vicinity of the jugular bulb.

The route from the excavated mastoid cells to the seat of the intracranial lesion is of course the only route to be followed by the surgeon in cases in which the infection has clearly spread along a pathway leading from necrotic tissue in the mastoid region to the deeper-lying area of disease within the cranial cavity.

There are those who claim, with some show of reason, that the removal of the tympanic roof exposes the cranial contents to a greater danger from infection than if a separate opening were to be made, by means of a trephine or chisel, into the middle or posterior fossa, the floor of the middle fossa or the anterior wall of the posterior fossa being allowed to serve as a barrier between the infected mastoid cells and the contents of the cranial cavity. But, as I have already stated above, this method of operating does not afford the best drainage (especially when the middle fossa is involved), and furthermore if one or the other of the cavities is already infected—as is presumably the case—additional infection is not likely to augment the danger. On the other hand, if the cranial contents are found to be normal, it is easy to prevent an extension of the infection from the middle ear by means of proper dressings. Then again, there is ample evidence to show that, when provision has been made for good drainage, infection does not so readily pass from the antrum or the tympanum to the soft parts within the cranial cavity when the latter are deprived of the wall of bone that separates them from the middle ear. In a number of instances which have come under my direct observation an opening has been inadvertently established in the middle or posterior fossa, during the course of the operation for a simple uncomplicated mastoiditis, and yet in not a single one of these cases have I known any symptoms to develop which would justify the belief that any infection had spread to these deeper structures after the establishment of this opening.

In operations for suspected intracranial lesions the preference should be given to chloroform as an anæsthetic, owing to the fact that it produces less congestion of the cerebral vessels, etc.

The course of events after the evacuation of a brain abscess by operative interference can perhaps best be shown by the report of a case: A child, four years of age, was admitted to my service in the New York Eye and Ear Infirmary on March 29th, 1902. The history of a long-continued, foul-smelling discharge from the right ear, with the development, some ten days previously, of a swelling behind and above the ear, was obtained. The child was prepared for immediate operation. The mastoid incision was extended upward to and above the parietal eminence. This unusually long incision was rendered necessary by the existence of a large subperiosteal abscess, filled with a most foul-smelling pus and occupying a space extending upward, from the mastoid tip, over three inches and from an inch to an inch and a half in width. The periosteal walls were found to be gangrenous. The bone, over a small area immediately below the parietal eminence, was of a purple-red color (evidently a beginning necrosis). The mastoid cells were opened and much cholesteatomatous material was evacuated; the posterior canal wall was removed and the tympanic cavity cleared of all granulations by means of the curette; the usual flap was made from the membranous external auditory canal. The dura was exposed above the tympanic roof and found to be normal. Owing to the necrotic condition of the periosteum the wound was left open throughout its entire extent.

Notwithstanding the fact that the child was a puny specimen of humanity and did not possess much recuperative power, the wound made fair progress toward healing. Suddenly, while she was sitting up in bed, on the morning of April 22d, the child collapsed. When I reached the patient, a few hours later, she was unconscious, with a pulse of 120 and a temperature of 106° F. The resident surgeon reported that, before she became unconscious, he had failed to find any evidence of paralysis or of anæsthesia. The patient was prepared for another operation. The opening in the tympanic roof, made at the first operation, was enlarged, a portion of the squamous plate of the temporal bone was removed, and the dura mater was exposed from the tympanic roof to the parietal eminence a distance of about three inches; its width measured about one inch. The dura mater immediately above the tympanic roof, which had been exposed at the first operation, was covered with healthy granulations, and the dura mater, on further exposure, was found to be healthy for a distance of from half an inch to three-quarters of an inch beyond. As the work of removing the bone advanced in an upward direction, it was found that the portion of the skull which at the time of the first operation had presented a purple-red color, was now noticeably softer and more friable, and immediately under the centre of this area was found a perforation in the dura mater. Granulations covered all this portion of the dura mater, but they were most exuberant in the immediate vicinity of the perforation. Pus exuded from the opening. A grooved director, introduced into this opening and pushed on toward the centre of the brain, met with no resistance until it had reached a depth of about two inches. As the next step an incision was made through the dura mater at this point. This liberated a small amount of odorless pus and some clotted blood. On introducing an encephaloscope into the abscess cavity its bottom was found to be filled with a blood clot. This clot, it was inferred, was the result of a recent hemorrhage and the cause of the collapse which had occurred a few hours perviously; it was therefore not disturbed.

During the period that followed the operation the wound was dressed daily up to the fifth day, when, as very little pus was present, the blood clot, with the aid of the encephaloscope, was removed. Upon taking away the last piece of this clot I was surprised to see that the lumen of the encephaloscope filled up with a clear fluid. I introduced cotton-tipped applicators in quick succession and in this way I was able to stop the flow for a sufficiently long time to obtain a view of the bottom of the cavity. It presented a smooth surface of a pinkish-white color, and I noted the fact that the fluid rose and fell with each inspiration and expiration. There can scarcely be any doubt that the descending horn of the lateral ventricle constituted the floor of the cavity into which I was looking.

A week later, as only cerebral fluid was exuding from the cavity, the gauze drain was removed, and on the next day I found that the cavity had closed. From this time onward the patient improved steadily, both as regards her general health and as regards the condition of the

wound. In fact, at the end of four months she had visibly gained in flesh and I had every reason to expect a favorable result. But at about the beginning of the fifth month after the operation, the patient developed a slight paresis of the left hand and leg; two weeks later the body temperature suddenly rose to 106° F. Further operative interference revealed a softening of the superficial brain structure, near the outer wound, but no abscess was discovered. The patient sank gradually, and at the end of another two weeks died. No autopsy was allowed, but the brain was explored through the wound of the operation. No abscess was found, but the lining of the lateral ventricle was covered with a purulent exudate; in all likelihood this condition extended throughout the whole ventricular system of the brain.

In all probability the abscess, in the case just narrated, was situated in the posterior portion of the first temporo-sphenoidal convolution. As regards the operation it seems to me that it would have been better if I had entered the cranial cavity below the parietal eminence. If I had done this I would not have found it necessary to remove the bone over the tympanic roof nor the lateral wall of the middle fossa, for a distance of over half an inch above the linea temporalis; and, besides, I would have left a smaller area of brain surface unprotected by bone.

The infection, in this case, evidently spread from the middle ear to the antrum, and thence to the cortex of the mastoid process, where it caused the formation of a subperiosteal abscess which extended upward as far as to the parietal eminence and even a short distance above it; it then spread to the bone in the region situated below the parietal eminence, causing a necrosis which extended from the outer table of the bone to and through its inner table: it then finally invaded the dura mater (pachymeningitis and an extradural abscess), causing necrosis of the portion invaded, and eventually involving the cerebral structures themselves (abscess of the brain).

II. *Septic Sigmoid Sinus Thrombosis.*—In cases of septic sigmoid sinus thrombosis the surgical measures required are the following: The mastoid operation having been completed in the manner already described in the earlier part of this article, the sinus wall is to be gradually removed by the use of a broad curette, and, when an opening has been made in the wall, it should be enlarged upward and downward with a pair of rongeur forceps. The sinus should be exposed for a sufficient distance beyond the knee, so that, if it should become necessary to introduce a curette at this point, there would be no obstructing curve to interfere with its use. In the downward direction the sinus should be exposed to view as far as the jugular bulb (see Fig. 3329). Near the bulb the operator must proceed cautiously, in order that he may avoid wounding the facial nerve in front of it; he must also remember that the foramen lacerum posterius does not give exit, from the skull, to the jugular vein alone, but that it also affords a passage, through its anterior portion, to the glosso-pharyngeal, the pneumogastric, and the spinal accessory nerves. The inferior petrosal enters the sigmoid sinus immediately above the jugular bulb.

As soon as the wall of the sinus has been fully exposed to view the question at once presents itself, Does it or does it not contain a thrombus? Unless the clot is large enough to occupy the entire lumen of the sinus canal, this question is a very difficult one to answer. From palpation alone it may be impossible to determine whether fluid blood is present or not; and it is practically useless to endeavor to make a diagnosis by aspiration of the sinus; for if the clot is centrally located the trocar will be likely to push it to one side, or if it hugs the wall of the vein the instrument will pass entirely through it. In either case, therefore, only fluid blood is likely to be obtained. It is therefore generally necessary to make the diagnosis from the general and the local symptoms alone (see Vol. III., p. 658). In some cases, however, the symptoms are not sufficiently marked to enable the surgeon to make a positive diagnosis. When this is the case he will be compelled to make a small incision in the sinus wall, the blood current being shut off above and below by the fingers of an assistant. If no clot is found, a simple pressure tampon will control the bleeding, and this tampon may be removed in the course of a few days. On the other hand, if a clot is found the sinus should be opened from a point a little above the jugular bulb to one situated a short distance above the knee, the bleeding during this procedure being under the control of the assistant. The curette is then introduced into the sinus through the incised opening and directed toward the torcular. At the instant when this is done, the assistant should cease to make pressure upon the sinus, thus permitting the surgeon rapidly to curette the interior of the vein in the direction named. In carrying out this part of the operation it is permissible to use a fair degree of firmness in scraping the external wall of the sinus, but a more delicate touch is necessary when the pressure is applied against the internal wall—that which lies next the cerebellum. Free bleeding is allowed for a few seconds so that the blood current may wash out any small particles of clot that may have escaped the curette. An iodoform gauze tampon (placed *over*, not *in* the sinus) is used to control the hemorrhage; if it should be inserted into the lumen of the canal it would hold it open, and when it became necessary to remove it the withdrawal of the tent would be likely to pull the clot out with it and so cause a recurrence of the hemorrhage. The mode of procedure recommended for the upper portion should also be applied to the jugular end of the sinus. The wound is then to be dressed as after a mastoid operation. If the wall of the sinus is found to be necrotic, as much of the diseased tissues as possible should be cut away. Very little pressure is required to control the hemorrhage; that exerted by the usual packing of gauze and by the outer dressings is all that is required.

III. *Ligation and Exsection of the Internal Jugular.*—This is the last of the series of operations which the surgeon may have to perform in order to rescue a patient from the fatal effects of an inflammation of the middle ear. The patient is placed on the operating table with the shoulders raised and the head turned to the opposite side; this sharply defines the anterior border of the sterno-cleido-mastoid muscle, which is the guide to be followed by the surgeon in cutting down on the vein. The neck should of course be thoroughly cleansed and the field of operation rendered aseptic. The incision in the skin extends from the sterno-clavicular articulation to a point midway between the angle of the jaw and the mastoid process. It is carried through the superficial fasciæ and the platysma myoides muscle. On reaching the deep cervical fasciæ the surgeon should do whatever further dissecting may be needed, with the handle of the scalpel, or with some other blunt instrument, rather than with the cutting edge of the knife. The latter is to be used only where the tissues are too firm to be torn apart. The branches of the superficial cervical nerve and of the external jugular vein are encountered in the course of the operation. About two-thirds of the way down the neck, and beneath the sterno-cleido-mastoid muscle, is the omohyoid muscle, which must be drawn down out of the way. Some small vessels are encountered, and if they get in the way, they should be ligated and divided. The jugular vein lies in the same sheath with the internal carotid artery and the pneumogastric nerve, and is covered by a fibrous sheath which also constitutes the posterior wall of the sheath of the sterno-cleido-mastoid muscle. The muscle is retracted and this sheath is divided and then opened throughout its entire length. The vein, it must be remembered, is very thin and easily punctured, especially if distended. It usually lies to the outside of the artery, the nerve lying between the two. At times the vein is collapsed and so small that it is difficult to find.

When the vein has been freed throughout this entire length its branches are next to be tied off (*i.e.*, the facial, the superior and middle thyroid, and the lingual veins). The internal jugular is then to be tied at two different

points—one a little above its union with the subclavian vein, and the other at its upper end. At each of these two points two separate ligatures are to be placed around the vein, which is then to be divided at each of these points; the knife (guided by a director, which at the same time protects the surrounding structures from injury) passing between the two ligatures in each case). The division is to be made at the lower point of ligation first, and the vessel is to be carefully dissected out from its bed until the upper point of ligation is reached. At this point the vein is again to be divided and the exsected portion entirely removed. Under no circumstances should this infected part of the vein be allowed to remain behind. If there has been no sloughing of the sinus, and if no pus is present in the wound, it may be entirely closed with sutures, or a drain may be placed at either end or at both ends, and the usual dressings applied.

Jansen (*Archives of Otology*, vol. xxx., p. 367), in a discussion on otogenous sinus thrombosis, in which the question of whether or not the jugular vein should be ligated before or after the opening of the sinus, or at all, constituted the most important point discussed, promulgated the following rules:

Ligation of the jugular vein is done—

I. As the *first step* of the operation: (1) in undisputed cases of jugular phlebitis; (2) in septicæmia.

II. *After exposure* of the sinus: (1) if the sinus appears healthy, having no perisinous affections, but being accompanied by rigors and marked oscillations of temperature indicative of a marked septicæmia; (2) in periphlebitis and parietal thrombosis under the same conditions.

III. *After incision* of the sinus: (1) if the septic thrombus is or was situated in the immediate neighborhood of the jugular bulb; (2) if, after the incision, the rigors do not cease, nor the temperature decrease materially.

The sinus is *opened* (1) when there is evidence of a septically disintegrated thrombus; (2) in gangrene of the sinus wall; (3) in repeated rigors, with marked oscillations of temperature and poor general condition; (4) when there is neuritis optica.

The weight of opinions as well as the weight of statistics would lead one to believe that the above-mentioned rules for guidance in these cases are very judicious, being neither too conservative nor too radical.

Randall (*University Medical Journal*, October, 1900), in an article entitled "A Review of Surgery, with Special Reference to Operation for Phlebothrombosis of the Lateral Sinus" and containing a most excellent summary, draws the following conclusions: Shock should be forestalled by avoiding loss of blood, by maintaining the body temperature, by the injection of a hot saline solution, and by the rapid use of the chisel, curette, and the rongeur with the minimum use of the mallet.* Metastases already formed, even in the lungs, are not necessarily contraindications for operation, since the secondary foci are generally less virulent and may heal. Brain abscess, especially in the cerebellum, should be constantly watched for, and may yield to prompt evacuation. Leptomeningitis alone seems to preclude recovery; and yet, in some cases, the symptoms of this serious complication may promptly disappear after operation.

The *carotid artery* and the *bulb of the jugular vein* because of their displacement forward into the tympanic cavity, have, in a few rare cases, been wounded in operations upon the drum membrane or in the middle ear. Bruhl mentions a case in which the carotid canal almost reached to the promontory of the middle ear. If this accident should occur, packing with iodoform gauze may control the hemorrhage, and continued pressure over the carotid will assist in the formation of a clot.

In cases in which the *internal ear* is the seat of a purulent inflammation, the labyrinth will have to be opened and drained; and if sequestra of the bony labyrinth exist, they will have to be removed. *Robert Lewis, Jr.*

* The inhalation of oxygen, especially in septic cases or in those in which the lungs are involved, is an excellent sustaining measure.

LITERATURE.

Broca: The Surgical Anatomy and Operative Surgery of the Middle Ear. Buck: Diseases of the Ear. Bacon: Manual of Otology. Bruhl and Politzer: Atlas and Epitome of Otology. Macewen: Diseases of the Brain and Spinal Cord. Jacobson and Steward: The Operations of Surgery. The Archives of Otology. The Journal of Laryngology, Rhinology and Otology, and various monographs by different authors.

MATCHLESS MINERAL WELLS.—Butler County, Alabama.

Post-Office.—Greenville. Hotels in Greenville.

These wells, two in number, are situated two and one-half miles from Greenville, a pleasant little town of about 4,500 inhabitants, in the pine region of Alabama. Greenville is located on the main line of the Louisville and Nashville Railroad, forty-four miles south of Montgomery. The following somewhat remarkable analysis of the water of these wells is said to have been made by Profs. E. A. Smith and J. B. Little, and to have been indorsed by Prof. Henry W. Leffmann:

One United States Gallon Contains:

Solids.	Grains.
Sulphuric acid	314.09
Ferric oxide	86.53
Ferrous oxide	81.38
Calcic oxide	24.53
Magnesic oxide	22.71
Potassic oxide	1.11
Alumina	3.65
Silica	5.04
Sodium oxide	4.09
Chlorine	2.47
Total solids	545.60

Carbonic acid undetermined. Specific gravity of water, 1.007.

This analysis shows the water to be a powerful chalybeate. It is bottled, and is said to have an extensive sale in the South. The water is recommended for dyspepsia, diarrhœa, anæmia, general debility, etc. As a local application it is used in indolent ulcerations and hemorrhoids, as an injection in gonorrhœa and vaginitis, and as a spray or gargle in throat affections. The dose as a tonic is one or two drachms three times a day, diluted with plain water; as a cathartic, six, ten, or twelve drachms in an equal quantity of water.

James K. Crook.

MATÉ—Yerba Maté. Paraguay Tea. The dried leaves of *Ilex Paraguensis* St. Hil. (fam. *Ilicineæ*). The plant yielding this important article is a shrub or small tree, growing both wild and cultivated in the country for which it is named, and in other parts of South America. The leaves are evergreen, lanceolate or oblong, blunt, and sparsely serrate. For use they are collected, dried, and generally broken into fine fragments.

It is not a drug in the proper sense of the term, but a beverage substance, being drunk in South America as a substitute for tea, for the sake of its one-half to one and one-half per cent. of caffeine. With this there occur about fifteen per cent. of tannin and a trace of volatile oil, so that the resemblance to tea is very close. It is the staple beverage of millions of people, who are quite as fond of it as any people are of other beverages, and it has the advantage of being very cheap. Various spasmodic attempts have been made to introduce it abroad, as a cheap substitute for tea, for the poorer classes, but they have not succeeded. At the present time (A.D. 1901), a much more powerful and sustained commercial attempt is under way, which bids fair to succeed. In doses about double those of tea, the characteristic action of theine or caffeine is to be obtained.

Henry H. Rusby.

MATICO.—"The leaves of *Piper angustifolium* R. et P. (fam. *Piperaceæ*)" (U. S. P.). This plant is a large shrub or small tree, growing upon the eastern slope of

the Bolivian Andes, and probably in Peru, at an elevation of 4,000 to 6,000 feet, the belt inhabited by the cinchona and coca plants. It is said to grow also in southeastern Brazil, but this is doubtless a distinct species. Several other species are collected and sold for it. The following is the description of the plant:

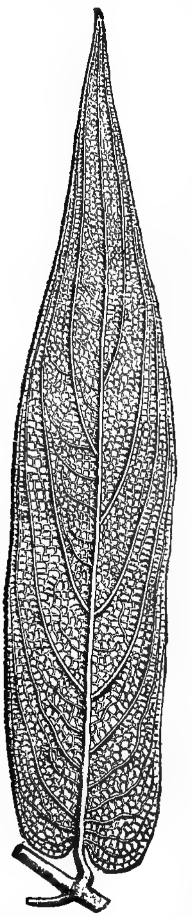

FIG. 3333.—Leaf of Matico Plant. (Baillon.)

Leaf from 12 to 20 cm. (5 to 8 inches) in length, very shortly and stoutly petioled, oblong-lanceolate, with obliquely cordate base, its lobes rounded, and a long acuminate, acute summit; margin entire or obsoletely crenate; bullate above, finely cancellate underneath, the veins densely brownish-hairy; odor faint; taste aromatic, pungent and bitterish. The flower spikes, which are frequently present, are about a fourth of an inch in diameter and two-thirds as long as the leaves. This distinguishes it from a spurious species often sold for it, the leaves being decidedly shorter and relatively broader and the spikes only about half as long and relatively thicker.

Matico contains from two to three per cent. of an essential oil, which is distilled for the market. It is yellowish-brown, of characteristic odor, and has a specific gravity of about .93. Its important constituent is the stearopten, which has been called "matico camphor" ($C_{12}H_{20}O$). The oil of the flowers is similar but has a specific gravity of 1.13. With the oil, there is considerable resin and tannin, and an amaroid, as well as *artanthic acid.*

The essential oil is a powerful abdominal stimulant, contracting the vessels in serous diarrhœa and in intestinal hemorrhage, in which action it is aided by the tannin. It has also been used locally as a hæmostatic, and as an ordinary vulnerary. It also possesses the ordinary properties of a bitter tonic. Its chief use, especially in France, has been as a substitute for cubeb and copaiba in the treatment of gonorrhœa and cystitis, but it is inferior to them, especially to the latter. We have official the fluid extract, dose 2 to 6 c.c. (fl. ʒ ss.–iss.), and a ten-per-cent. tincture, made with diluted alcohol, the best use of which is as a stomachic, in doses of ℥ ss.–i. *Henry H. Rusby.*

MATZOÖN. See *Milk.*

McCALLISTER'S SODA SPRINGS.—Jackson County, Oregon.

POST-OFFICE.—Lake Creek. Camping grounds.

ACCESS.—Viâ Southern Pacific Railroad to Central Point; thence by private conveyance over a fair wagon-road twenty-five miles east to springs

McCallister's Springs are located in a picturesque mountain region, 5,400 feet above the level of the sea. This region is noted for its pure, dry atmosphere and its freedom from miasmatic diseases. The springs are two in number, and flow about 120 gallons per hour each. The water has not yet been analyzed. We are informed by Mr. J. G. McCallister, the proprietor, that the waters have a wide reputation among the residents of the surrounding country in the treatment of chronic malarial poisoning. It is said that malaria is unknown in the neighborhood, and almost every person suffering from fever and ague is relieved after a few days' stay at the springs. We may easily believe, however, that these good results are at least partially due to the bracing mountain air of the neighborhood. The place is much resorted to by dyspeptics and rheumatic patients. The water is always cold, and is said to possess excellent properties as a tonic and appetizant.

James K. Crook.

MEASLES.—(Synonyms: Morbilli, Rubeola; Ger., *Masern, Flecken;* Fr., *Rougeole;* It., *Rosalia;* Sp., *Sarampion.*)

DEFINITION.—Measles is an eruptive contagious fever. It is characterized by a period of incubation, of invasion, of eruption, and of decline. Its peculiar symptoms are manifested upon the skin and mucous membranes. It is highly contagious and, as a rule, attacks an individual but once.

HISTORY.—There is no evidence that measles was recognized as a distinct disease before the time of Rhazes (A.D. 900). Although this writer described measles and smallpox together, he probably appreciated their differences. Late in the tenth century Avicenna described measles, but it was not until the close of the seventeenth century that this malady and scarlatina were definitely determined to be separate affections, when Sydenham and Morton (1670–74) declared the latter to be a disease *sui generis.* Thenceforth descriptions of measles became more clearly defined, and to-day its literature is very voluminous. The origin of measles is buried in obscurity. At present its distribution is almost world-wide; only the remotest corners of the earth have remained exempt from its ravages. It appeared in America soon after the arrival of the first settlers, and advanced steadily with the pioneers of civilization. It did not reach Oregon until 1829, or California and Hudson's Bay Territory until 1846. Greenland, as late as 1864, had not been invaded by it.[1]

CLINICAL HISTORY.—*Typical Course.*—Stage of Incubation. Although it has been asserted by Vogel and others that for several days after infection the contagious principle remains absolutely quiescent, it must be concluded that an attack of measles begins at the moment when its specific influence is brought to bear upon the body of its recipient. Though not demonstrable and, certainly, so far as our present methods of research enable us to determine, quite without immediate appreciable results, this influence continues and grows until it acquires a force capable of upsetting the equilibrium of the economy and of initiating characteristic symptoms. The interval included between the date of infection and that of the outbreak of symptoms is called the *period* or *stage of incubation.* This period varies between seven and twenty-one days; very rarely it may be more brief than seven days, or prolonged beyond twenty-one days. Panum, whose opportunities for observation, during an epidemic of measles in the Faroë Islands, were unusually good, determined that the eruption occurred thirteen or fourteen days after infection. This would give a period of incubation of from nine to ten days. Girard,[2] in one hundred and eight cases of measles, determined that the exanthem appeared in from thirteen to sixteen days, never earlier, never later; in only three cases was it as late as the sixteenth day. This would correspond to an incubative period of from nine to twelve days. Chomel taught that the eruption may appear as early as seven days after infection, and in many cases may not appear until after fifteen days. The results of inoculation of unprotected individuals, with the tears and catarrhal secretions of persons affected with measles, are, as might be supposed, somewhat different. The inoculations practised at Edinburgh, in 1758, by Home, with the blood of infected persons, have been repeated with blood, tears, mucus, epidermic scales, etc., by different experimenters, with varying results. Katona failed in only seven per cent. of eleven hundred and twenty-two inoculations.[3] Prodromal symptoms began in his cases on the seventh day. The difficulty of discovering the exact time of infection necessarily renders the determi-

nation of the duration of the stage of incubation very uncertain. Many instances of apparently protracted incubation are to be explained by the fact that the individual became infected only after repeated exposures. It may be concluded that most cases develop prodromal symptoms on the ninth or tenth day after infection. These will rarely appear on the seventh or eighth day, somewhat more frequently on the eleventh or twelfth day, and only exceptionally, after more prolonged intervals or earlier than the seventh day.

Stage of Invasion.—This stage may begin abruptly with fever, or it may be ushered in by gradually developing evidences of disturbed nutrition. Anorexia, nausea, headache, general malaise, shiverings may accompany or follow symptoms of conjunctival, nasal, and bronchial catarrh, during which the fever will become manifest. Although it has often been claimed that vague signs of disorder accompany the incubative stage, it is usual for the invasion to be marked by a sudden onset of fever, in which, during the first day, a temperature of from 39.1° C. to 40° C. (102° to 104° F.) will be attained. Wunderlich has shown that this preliminary elevation of temperature "allows us to forecast the subsequently occurring elevations with very great probability, since these, on an average, are wont to exceed the height of the initial rise by about 0.8° to 1° C. (1.5° to 1.8° F.), and only exceed this a trifle even when most extreme."[4] Catarrhal symptoms develop almost immediately; indeed, the implication of the mucous membranes is the characteristic feature of this stage. The mucous membranes of the eyes, nose, and throat, of the larynx, trachea, and bronchial tubes, and sometimes of the digestive organs, become almost simultaneously affected. The conjunctivæ are injected and reddened, a free discharge of tears follows, shortly succeeded by a scanty muco-purulent formation about the tarsal borders, which is more free in scrofulous persons. More or less photophobia will be developed. Monti has drawn attention to the small red spots visible along the ciliary border. The eyelids become somewhat reddened and swollen. Köningsten has declared the conjunctival hyperæmia to be a specific effect of the measles contagium, and not simply catarrhal. Sneezing and snuffling, which are often the first symptoms observed, indicate hyperæmia and inflammation of the nasal mucous membrane. A thin watery discharge from the nose is also present. After a day or two this becomes muco-purulent. The membrane is seen to be reddened, and inspired air excites a painful, burning sensation. Cough denotes the involvement of the respiratory tract, and is intense, usually, in proportion to the severity of the attack. It is at first dry and troublesome, but afterward becomes associated with secretion. Croupy cough and respiration sometimes occur and denote swelling of the tracheal and laryngeal mucous membrane. Rarely, œdema of the glottis may suddenly develop and threaten life, or call for tracheotomy. Nausea, vomiting, and total loss of appetite indicate perturbation of the gastric mucous membrane, and the frequent appearance of diarrhœa denotes the occurrence of intestinal catarrh. The buccal cavity does not usually show pronounced alterations. The tongue quickly becomes coated with a thin whitish fur, through which the papillæ penetrate. From the first there are often pain and difficulty of swallowing, and the faucial mucous membrane assumes a more vivid coloring; and by the end of the second day careful inspection will detect small blotches of irregular outline and deepened color upon the hard and soft palate. Girard asserts that a punctate redness is visible on the palate from four to six days before the eruption. Due attention has only of late been given to the condition of the mucous membrane in this stage. The posterior wall of the pharynx is more intensely reddened than the arch of the palate. From twelve to twenty-four hours before the appearance of the cutaneous eruption, an eruption invades the palatal mucous membrane. The efflorescences are irregular, varying in size from that of a pin-head to that of a hemp seed or a lentil, and are isolated or confluent. They are sometimes papular. These lesions grow pale after from twelve to twenty-four hours. The buccal mucous membrane is sometimes similarly affected; that of the tongue, however, is never invaded.[5] While the eruption is most copious upon the soft palate and uvula, it has been observed upon the general visible surface of the respiratory and digestive tracts, and its existence at this time justifies the opinion expressed by Hardaway and others, that it would be better to designate the period of its development as the stage of the "exanthem of the mucous membrane." The throat is felt by the patient to be dry, and the cough, which constantly grows in intensity, may have a metallic ring and may be accompanied by decided hoarseness. Sibilant and sonorous, and, occasionally, subcrepitant râles, may already betray bronchitis. Not infrequently the symptoms become complicated with epistaxis, which rarely becomes alarming. Nervous agitation may now be extreme, or the child may remain dull, inattentive, or somnolent. Convulsions not very rarely appear, but, when observed thus early in the disease, are not often of grave augury.

The fever, which may have developed with the symptoms described, or may have preceded them, becomes in a few hours quite intense, in severe cases attaining a temperature of from 39° to 40° C. (102.4° to 104° F.). An exceptional case is reported by Hunter (*British Medical Journal*, 1898, i., p. 1134) where the fever, which was 107° F. before the rash appeared, after four days rose to 110° F., was accompanied by unconsciousness and followed by convulsions; the patient, a child, was treated with the cold pack and recovered. Vomiting and severe frontal headache often accompany the fever. The child will be fretful and peevish, or may remain drowsy and apathetic. All the symptoms enumerated may be of an exceedingly mild character, may even escape observation, or they may rapidly develop a high degree of intensity. Once developed, they continue unabated until the end of the second or beginning of the third day, when in most cases there will be a sudden amelioration. Indeed, fever may quite disappear, and delusive hopes of an immediate recovery may be entertained. The child will regain some of its gayety of manner and will play about the room at times. The catarrhal symptoms, however, will in most cases persist, though with diminished vigor. This period of apparent improvement is very deceptive, but by careful consideration of all concomitant phenomena, the experienced attendant will learn to avoid error. During the third day the fever will increase and remain unabated, while the appearance of the cutaneous eruption will usher in the next stage. The high temperature of the stage of invasion is not again equalled until the acme of the disease, which occurs toward the close of the second day of the eruption. Careful consideration of the symptoms, of the course of the fever, of the development of the catarrh, the coughing and sneezing, the lachrymation, the injection of the conjunctivæ, and especially of the efflorescences upon the faucial mucous membrane, will often justify a very confident surmise as to the true nature of the disorder before the cutaneous eruption appears.

Koplik's Sign.—Dr. Koplik, of New York,[27] has recently (1896) drawn attention to "buccal spots" of characteristic appearance and much diagnostic value. These are now generally known as "Koplik's Spots," or "Koplik's Sign," and the account here offered is taken from his writings. "Scant attention has been given to the most important elements of the eruption as it appears on the mucous membrane of the inside of the cheeks and on that of the lips. A thorough understanding of the eruption on the buccal mucous membrane will aid in separating an invading measles from a mass of eruptions resembling measles which appear on the skin in infancy and childhood. Any positive sign of the invasion of any infectious or contagious disease is a step to proper isolation and prophylactic hygiene.

"If we look in the mouth at this period (first twenty-four to forty-eight hours of the invasion), we see a redness of the fauces; perhaps, not in all cases, a few spots on the soft palate. On the buccal mucous membrane

and the inside of the lips, we invariably see a distinct eruption. It consists of small, irregular spots, of a bright red color. In the centre of each spot there is noted, in strong daylight, a minute bluish-white speck. These red spots, with accompanying specks of a bluish-white color, are absolutely pathognomonic of beginning measles, and when seen can be relied upon as the forerunner of the skin eruption. . . . No one has, to my knowledge, called attention to the pathognomonic nature of these small bluish-white specks, and their background of red, irregular-shaped spots. They cannot be mistaken for sprue, because they are not as large nor as white as sprue spots. These specks of bluish-white, surrounded by a red area, are seen on the buccal mucous membrane and on the inside of the lips, not on the soft or hard palate. Sometimes only a few red spots, with the central bluish point, may exist, six or more, and in marked cases they may cover the whole inside of the buccal mucous membrane. If these bluish-white specks, on a red spotted background, are at the height of their development, they never become white opaque as in sprue, and in this respect, when once seen, are diagnostic, nor do they ever coalesce to become plaque-like in form. They retain the punctate character. I have noted and demonstrated these spots on the buccal mucous membrane when the other symptoms were so slight that physicians have doubted the diagnosis. I have been invariably confirmed in my diagnosis by the subsequent appearance of the skin eruption.

"The eruption just described is of the greatest value at the very outset of the disease, *the invasion.* As the skin eruption begins to appear and spreads, the eruption on the mucous membrane becomes diffuse, and the characters of a discrete eruption disappear and lose themselves in an intense general redness. When the skin eruption is at the efflorescence, the eruption on the buccal mucous membrane has lost the characters of a discrete spotting and has become a diffuse red background with innumerable bluish-white specks scattered on its surface. The buccal eruption begins to fade even while the skin exanthema is at its height, or at least while it is running a late course. The mucous membrane retrogrades to the normal appearances long before the eruption on the skin has disappeared. This being the case, it will be seen that the buccal eruption is of the greatest diagnostic value at the outset of the disease, *before* the appearance of the skin eruption and at the outset and height of the skin eruption." These spots are sometimes referred to in English medical literature as Filatow's spots.

Stage of Eruption.—It rarely happens that the eruption is discovered on one in whom premonitory symptoms have not been observed. In such cases inquiry will often elicit the fact that for some days previously the child had not been in his accustomed health, though attracting no special attention. A slight cough, a mild coryza, a conjunctival irritation can be recollected.

In the great majority of cases the eruption begins to appear on the fourth day of the disease, when the fever and general catarrhal symptoms are approaching their height. It is first seen on the forehead, temples, and cheeks as pale red spots, appreciable to the eye, but not to the touch. These spots rapidly increase in number and in intensity of color, and include the face, head, neck, breast, shoulders, and trunk. By the fifth day, or second day of the eruption, in ordinary cases, the face becomes swollen and more or less covered with an eruption that has now acquired a raspberry-red color, and a configuration and distribution of peculiar character. The spots are now quite perceptible to the finger and sometimes decidedly papular, so that at times the hard, shotty papules of beginning smallpox eruption are simulated. This resemblance quickly disappears and the papule becomes surrounded by a red areola of small size, the whole spot not exceeding the size of a flake of bran. These spots tend to group themselves into crescentic shapes, or segments of circles, the general distribution of which varies considerably in intensity. At other times the spots will present a soft, almost uniformly elevated surface that may not suggest a papular eruption. They have an irregular outline and are surrounded by normal, unaltered skin, except where the eruption becomes confluent, as upon the cheeks in ordinary cases, or over more diffused areas in severe ones, or at the site of some pre-existing hyperæmia, as that from the irritation of a sinapism or other stimulating application. When confluent the eruption shows a dusky red surface, elevated, and more or less infiltrated.

During the fifth day the eruption extends along the trunk and upper extremities, but does not develop upon the legs until the sixth day. Here it is usually not nearly so intense either in extent or in coloration. The groups of macules are much less numerous, and their color is paler. The general symptoms will have continued with unabated vigor. If diarrhœa have not already been present during the prodromal stage, it is now very apt to occur, and may prove very annoying. The temperature remains unabated, reaching its acme at the height of the eruption. The catarrhal symptoms persist, the secretions often becoming muco-purulent. At this period vesicles the size of a hemp seed may appear at the mucous follicles of the buccal cavity, in the middle of a macule or papule. Sibilant, sonorous, and subcrepitant râles indicate the extent of bronchitis present. The maximal temperature is attained from the end of the fourth to the sixth day of the disorder (earlier in mild cases than in severe ones), and continues for from one and a half to two days, when there is a sudden diminution of fever and a rapid mitigation of all the symptoms.

At the height of the eruption, the finger pressed upon a spot causes the redness to disappear and to be replaced by a pale yellow color, which rapidly gives place to the returning hyperæmia. With the reduction of temperature the eruption begins to pale, and by the eighth day will have become quite indistinct, and the swelling of the face and neck will have, in great part, disappeared. With defervescence, which usually begins in the night, the eruption rapidly fades, first in those parts first invaded, so that by the ninth day the only traces to be found are pale-yellow spots, which will not entirely disappear upon pressure. Occasionally, when the eruption is at its height, a number of tiny, pin-point vesicles may develop more or less abundantly. They are not of importance, and commonly depend upon excessive temperature of the room or too heavy bed-clothing. At other times the eruption becomes hemorrhagic and assumes a petechial character, strongly suggestive of the exanthem of typhus fever. This condition is usually seen upon the extremities, but may involve the eruption over the whole body. The spots assume a more livid coloration, and are not affected by pressure. No especial significance is to be attached to this form of eruption, the course being favorable, though for many days after the active symptoms of the disease have ended the surface remains mottled with the dark spots. As the intensity of the eruption is usually proportionate to the severity of the fever, in milder cases the cutaneous lesions are more scattered and of less vivid coloration; and in the mildest cases fever, catarrh, and exanthem may be hardly appreciable, the eruption especially being pale, scattered, and limited almost entirely to the face, neck, and superior portion of the trunk.

Throughout the attack the tongue remains moist and thinly coated with a whitish fur. This coating is not stripped off as in scarlet fever, nor does the tongue become dry and brownish, and cracked as in typhoid fever, unless complications of grave character supervene. After defervescence, it soon reacquires its normal appearance. Even at the height of the eruption, the tongue usually remains red at its borders. General enlargements of the lymphatic glands are often observed. The submaxillary and anterior cervical glands are most markedly swollen. The urine is reduced in quantity, is strongly acid, and of high specific gravity. Occasionally, and especially early during the prodromal stage, retention of urine may be noted. At other times there is great irritability of the bladder, with frequent micturition and pain. Albumi-

nuria will rarely occur, but may almost always be attributed to the febrile condition, and not to specific influence.

The eruption is most characteristic in those of fair complexion, though it always retains its peculiar features even in the darker individuals of the white races. In dark-skinned races, however, it becomes much modified, principally, of course, in its coloring. In negroes and those of mixed African descent, the characteristic color disappears in proportion to the intensity of the normal cutaneous pigmentation. The eruption, in losing its vividness, seems to acquire a more pronounced papular character, and the summits of the tiny papules often appear, by contrast, of a whitish, translucent color, from the exudation into them. Through the black skin the hyperæmic redness will be obscurely visible. The true nature of the eruption will usually be recognized without difficulty by its distribution, the œdema of the face, the concomitant fever and catarrhal symptoms, and the eruption upon the mucous membrane.

Stage of Decline.—Though the fever and eruption rapidly disappear, it is not until after several days that the catarrhal symptoms subside. As these become less urgent the appetite gradually returns, the various functions become restored, the strength and spirits increase, and the patient, though feeble, enters upon convalescence. This *stage of decline* terminates with a scanty desquamation. This begins about the tenth or eleventh day, and after mild cases may be almost imperceptible. Usually it appears, especially about the forehead and cheeks, as an exfoliation of fine, branny, epidermic scales, quite unlike the desquamation of scarlatina. After a few days it is completed, and health becomes reestablished. Careful search is often necessary to detect this desquamation upon the body and limbs.

Atypical Course.—Very many cases depart from the typical course, as described, in one or more respects; indeed, the general characters of the malady may be irregular. The initiatory symptoms of the stage of invasion may be so insignificant as entirely to escape observation, when it may appear that the eruption abruptly ushers in the disease. Cases of this kind are not very uncommon. On the other hand, the stage of invasion may be prolonged until the sixth or seventh day. Here, however, appearances are apt to be misleading, as in cases in which the specific process develops during an attack of simple coryza or bronchitis. The eruption may be very long delayed by pre-existing internal disorders of more or less gravity—pulmonary phthisis, acute or chronic visceral inflammations, etc.—when the whole course of the disease is apt to be irregular. The stage of eruption may even be wanting. In such cases, a correct diagnosis depends rather upon etiological considerations than upon specificity of symptoms; occurring sporadically, these cannot be identified. But it occasionally happens, in families, boarding-schools, asylums, etc., where measles prevails, that children unprotected by a previous attack and exposed to the contagion, in due time develop all the symptoms of measles except the eruption, and upon recovery remain protected from future attacks. Such forms are designated as *morbilli sine exanthemate.* When, on the other hand, the eruption occurs without a well-marked or recognized catarrhal stage, and without the development of catarrhal symptoms during its course, similar diagnostic difficulties arise, and one is only justified in recognizing *morbilli sine catarrho* in the presence of unquestionable conditions. Indeed, there are those who claim that unless catarrhal symptoms are present, a diagnosis of measles cannot be maintained. In these forms the course is usually mild. Rarely, a very interesting departure from a typical course is the appearance of a rash almost simultaneously with the outbreak of the stage of invasion. This is usually observed, upon the morning of the second day, upon the cheeks, forehead, temples, neck, etc. At first it is like the ordinary measles rash in shape and distribution, but in color it is pale. With the mitigation of symptoms that occurs by the close of the second day, it ceases to develop, and may even recede partially and remain as pale, pinkish blotches, until the regular rash appears and supplants it. Such cases present generally no other abnormality of course. Irregular distribution of the rash is not very infrequently met with. It may invade the trunk alone, or may spare the lower extremities, or it may not appear in the order described. These are unimportant modifications and of themselves add no gravity to the prognosis.

As in mild cases the rash may be pale, scanty, and not well developed, so in severe ones it may be confluent, brilliant, and abundant; at times it may be livid, and the patches may coalesce into more or less extensive areas of eruption over the trunk and limbs, as well as upon the face. These patches feel elevated and infiltrated. Here and there tracts of unaltered skin will be sharply circumscribed by them. Pressure upon these dark, livid patches will generally cause them to grow pale; but there may be occasionally observed evidences of hemorrhagic exudation in the increased lividity of the patches, and in the fact that they are uninfluenced by pressure. The eruption may assume a petechial character strongly suggestive of the exanthem of typhus fever. The hemorrhagic spots often correspond closely to the eruptive lesions in configuration and extent, and remain for many days after the activity of the malady is passed. This condition is developed early, and may involve the entire area of eruption. It cannot be assigned to any recognizable cause, and, indeed, is not of serious augury. During convalescence these hemorrhagic spots slowly undergo the changes of extravasated blood pigment, and disappear within a week or two. This variety should not be confounded with that severe and extremely fatal form of measles known as "black measles," or "malignant hemorrhagic measles," which is fortunately very rare, and which more especially attacks persons with bad hygienic surroundings, such as soldiers in camps, convicts, children crowded into badly constructed asylums, etc.; also those exhausted by intemperance, want, exposure, and similar influences. Here all the symptoms differ from those of the form just described, in which, although the petechial character of the eruption is marked, there is always the corresponding, associated intravascular hyperæmia of the eruptive lesions. These differ altogether from the purplish and blackish ecchymoses of malignant measles. It has even been asserted that the pigmentation in them is not due to extravasated blood, but to the decomposition of red blood cells exuded in a purely inflammatory process. In malignant or "black measles," the symptoms of profound systemic intoxication are associated with the irregularly distributed rash, which is never perfectly developed. At first appearing possibly in the regular way, its abnormal course is soon declared. The eruption ceases to develop, and the lesions already present fade away or change into ecchymotic spots, which may correspond to the size of the primary lesion or assume linear or irregular shapes, and involve larger tracts of skin. These ecchymoses are most abundant and largest upon the trunk and on its most dependent parts, though they may appear anywhere. Signs of failure of circulation, quick and feeble pulse, coldness and lividity of the extremities, delirium, stupor, and subsultus tendinum develop. Hemorrhages may occur into and upon mucous and serous membranes, and death follow early from profound toxæmia. Malignant measles may run a very rapid course, as is especially the case in some epidemics.[6] Convalescence, however, may be established, but will usually prove tedious.

The course of measles may be made abnormal by the existence of acute or chronic disease at the time of infection. Here much alteration in the features of the exanthem may be noted. The prodromal stage may be unusually protracted, or the eruption may be imperfectly developed, both as to intensity and in distribution; or the mucous membrane may have to bear the brunt of the attack; at other times the attack seems to receive a sudden check. The eruption fades, and is succeeded by great pallor. Such sudden arrest is usually due to an intercurrent malady, and will be more suitably considered

with the complications of measles. It has already been said that convulsions occurring at the outset of the disease are not especially ominous. If, however, they occur repeatedly, or during the later stages of the disease, they are of grave augury, and often precede or accompany complications that may lead to a fatal issue. In rare instances the eruption is unduly prolonged; it has been known to persist as late as the tenth day.

DIAGNOSIS.—Although the nature of the disease may very often be conjectured during the prodromal stage, it is only during the eruptive stage that the diagnosis of measles can be definitely determined. See, however, Koplik's sign, *supra*. Meunier, in 1898, reported that during the incubation period of measles there was constantly observed a loss of body weight, and that this loss in weight was quite independent of any other cause. In a series of thirty cases, given by Meunier, there was an average loss of 310 gm. (about ten ounces), the maximum being 700 gm. (about twenty-two ounces), and the minimum 90 gm. (nearly three ounces) (*Gaz. hebd. de Méd. et de Chirurgie*, 1898, p. 529). In typical cases the combination of fever, eruption, and catarrh of the mucous surfaces affords characteristic and easily recognizable features, when considered along with the history and course of the malady. During the prodromal stage the symptoms may be mistaken for those of simple coryza or of bronchial catarrh. Indeed, they are often identical with these, and to this extent can cause no confusion. They may be suspected to depend upon the contagion of measles, if they develop in one who is known to have been exposed to it, or if during the second or third day the eruption upon the soft palate is observed. If, however, the fever and catarrh persist after the fourth day without an eruption, measles may be excluded nearly always. Upon the appearance of the eruption, measles may be confounded with Rötheln or German measles, scarlatina, typhus fever, and in its earliest stages with varicella and variola. It will also be necessary to exclude drug eruptions, such as those from copaiba, quinine, etc. The diagnosis between measles and Rötheln presents many difficulties. It is true that recent writers describe Rötheln as having well-marked characteristics; but it must be observed that many do not agree as to the exact history and symptomatology of this affection. This want of agreement makes it difficult to determine the standard of Rötheln for comparison. The diagnosis must rest upon a general consideration of all the symptoms. In Rötheln the prodromal stage only exceptionally exceeds twenty-four hours; it often is less than twelve hours. In many cases Rötheln is afebrile throughout, and in most cases it is barely febrile. Upon this point, however, there is no consensus of opinion, some authors describing epidemics of Rötheln in which fever of great intensity prevailed.[7] Cheadle even claims as a distinguishing mark of the affection "a higher range of temperature and its longer persistence" than in ordinary measles.[8] The catarrhal symptoms in both affections differ only in intensity. The faucial mucous membrane in Rötheln shows a diffused redness rather than the flecked eruption of measles. Enlargement of the cervical glands has been noted as of constant occurrence in Rötheln, but it is likewise very often observed in measles. The eruption of Rötheln is pale red, rather than dark red, as in measles, while the patches are more circular and less discrete, and with less irregular borders. It is also more rapid in its course, and is but rarely followed by desquamation. It should be remembered, however, that upon no symptoms of Rötheln, as distinct from those of measles, have writers agreed, and that no case of the disease presents features sharply defined from those of measles. Up to the present time, therefore, one is not justified in diagnosticating Rötheln in any isolated case, unless the patient has already had measles or has been exposed to the influence of a prevailing epidemic of the former disease.

Of the other eruptive fevers, scarlatina is most like measles. Usually, however, the diagnosis is easily made. In scarlet fever the eruption appears by the second day. The fever is accompanied by sore throat, more or less severe, with intense redness of the faucial mucous membrane. The eruption is of a bright scarlet color, and more regularly diffused; the papules are much finer. In well-marked cases there is a universal redness. In measles the eruption is of a dusky red and arranged in circumscribed patches with intervening healthy surfaces. At times the measles eruption becomes almost universally confluent. The darker coloration is, however, still maintained, and the surface is distinctly infiltrated and elevated, giving to the hand a sensation of roughness. Moreover, there will always be areas of less intense eruption, where the characteristic arrangement may be recognized. Rarely, scarlatina develops a discrete eruption closely simulating that of measles. The patches will then be of larger superficial area, of a brighter color, and less infiltrated. There will nearly always be present concomitant symptoms that should dissipate doubt. After the first few days the tongue, in scarlatina, develops the characteristic strawberry appearance, whereas in measles the tongue remains coated throughout. The eruption of scarlatina is accompanied by a more or less intense itching, that is usually absent in measles. The fever of scarlatina persists for some days after the eruption has attained its height, while in measles the completion of the eruption is marked by almost immediate defervescence. The desquamation of scarlet fever is composed of large, sometimes of enormous, flakes of epidermis, while that of measles is branny and not abundant. In scarlatina the faucial mucous membrane is inflamed, sometimes diphtheritic; in measles there is catarrh of the whole respiratory tract. Finally, measles is not followed by dropsy and nephritis, which are so often observed after scarlatina.

During the first twenty-four hours the smallpox eruption may resemble that of measles, but its papular, shotty character soon reveals it. Varicella, or chickenpox, may also at first resemble measles, but its vesicular eruption quickly develops. The eruption of typhus fever is often perplexingly like that of measles. Doubt, however, is apt to arise only when the former affection is known to prevail, or where the conditions favorable to its development are present. The typhus eruption is especially like that of measles where the distribution is normal, but where extravasation gives a petechial character. Such cases of measles can be recognized through their concomitant symptoms. Bronchial catarrh is present in both. In typhus the nasal catarrh is absent, as is also the conjunctivitis, though the eyes may be injected. The eruption on the face is also absent or scanty. The course of the fever is also different in the two affections, the typhus exanthema not appearing until the seventh day.

A peculiar eruption following the ingestion of copaiba offers points of great similarity to that of measles, though at times it equally resembles that of smallpox. The resemblance is heightened by the catarrh of the conjunctival, nasal, faucial, and bronchial mucous membrane, and by the existence of fever. In the copaiba eruption the incubative period is lacking, and the rash, brighter red from the first, while exhibiting many patches indistinguishable from those of measles, develops many lenticular papules totally dissimilar. At scattered points vesicles will almost always be observed. Simple roseola is less intensely colored and is more fugacious than measles; it is without prodromal stage or catarrhal symptoms, and is usually afebrile. Moreover, many cases of what was formerly called roseola must now be relegated to the domain of Rötheln. Erythematous eruptions from quinine and other drugs somewhat resemble the measles rash; but they differ widely in most other respects. Erythema papulatum may also resemble measles, but its seats of election, the face, the forearms, the dorsal surfaces of the hands and of the feet, along with its afebrile course and general history, will serve to distinguish it.

COMPLICATIONS.—The course of measles may be made irregular by complications; or, occurring in persons already suffering from other diseases measles may itself

become the complicating affection. Disorders complicating measles may be simply the results of intensification of morbid processes characteristic of the disease, or they may be intercurrent. By far the most important are those involving the mucous membranes. "A high grade of purulent conjunctivitis may develop, and even false membranes may form upon the lids. True diphtheritic inflammation is not unknown. Purulent infiltration of the cornea and keratomalacia may be observed, but iritis occurs only secondarily." [9] Thomas has reported, as a sequela of measles, paresis of accommodation and, in consequence of this, strabismus. Rarely, the nasal mucous membrane may undergo excessive inflammation. Stomatitis is more often developed, and may range from ordinary catarrh to ulcerative and even gangrenous inflammation. True *cancrum oris*, or *noma*, is more apt to occur as a sequela. In stomatitis the mucous membrane becomes highly injected. The tongue is thickly coated with a whitish fur, and has a sodden look. The gums are spongy and swollen, and often bleeding at their borders. Superficial ulcerations appear upon the buccal mucous membrane, and aphthous deposits accumulate. Saliva is copiously discharged, and fetor of the breath becomes pronounced. The sublingual and submaxillary glands often become greatly enlarged and tender. Much distress is often experienced, and mastication becomes almost impossible. The stomatitis usually outlasts the measles and subsides in a week or ten days. More profound and gangrenous ulcerations form extreme degrees of these inflammations. *Per se* the stomatitis would not be of much account; but it is of great importance from the fact that the inflamed mucous membrane may become the seat of secondary infection, notably diphtheria. The more severe grades of pharyngitis only rarely complicate measles. *Diphtheritis faucium*, however, is not very uncommon. It usually leads to a fatal termination. Laryngeal and tracheal symptoms may at times acquire undue prominence, usually from catarrhal inflammation of a high grade. In such cases the voice, cough, and respiration become "croupy." Œdema of the glottis has been known to occur, and rarely may be so severe as to terminate life by asphyxia. True laryngeal diphtheria is also a recognized and very fatal complication of measles.

Bronchitis can be considered a complication only when it assumes a rôle more important than the essential disease. Severe bronchitis is quite common, and very often persists for some time after the eruption has disappeared. Serious results are not apt to ensue, but occasionally it may become grave more or less rapidly, or become suddenly intensified in badly nourished children, or in those not properly looked after. In such cases the fever is unduly prolonged, and the symptoms become those of ordinary acute bronchitis. A much more formidable complication is capillary bronchitis. Usually occurring during the decline of measles, it protracts the febrile movement while the eruption pursues its regular course, or, as more frequently occurs, prematurely fades with more or less abruptness; the life of the patient being thrown into imminent peril. This affection is most dangerous, both from its own intensity and from its tendency to develop atelectasis pulmonum and catarrhal or lobular pneumonia. Whether arising in this manner or not, lobular pneumonia is the most common of the graver complications of measles, and is responsible for the greater number of deaths from the disease.* It occurs mostly in badly nourished, delicate children, and in those who have been unduly exposed during the attack. Nevertheless, pneumonia often develops, in consequence of some individual predisposition, in those whose hygienic surroundings are perfect; and it cannot be denied that the contagious principle at times exerts a special morbific influence upon the pulmonary parenchyma, as is shown in the greater prevalence of complicating pneumonia in some epidemics than in others. Catarrhal pneumonia may appear at any stage of measles, in patients of any age, and at any period of an epidemic. It is more apt to occur, however, in those under five years of age, in children of poor parents, and at the height of an epidemic. Catarrhal pneumonia, complicating measles, does not necessarily greatly increase the gravity of the attack. It is probably, in more or less restricted extent, a very common concomitant of measles, and in many cases in which fever is protracted beyond the usual period, with persistence of symptoms of bronchitis, limited areas of lobular inflammation are present. The severity of the attack will be proportionate to the severity and extent of the pneumonia, which usually invades both lungs irregularly, beginning at the bases. There will always be present bronchitis, the symptoms of which are so prominent that the pneumonic symptoms may be very obscure. Crepitant râles, with slight dulness and bronchial breathing, may nearly always be detected during the attack. Dyspnœa is often decided, and there is greater tendency toward cyanosis than in lobar pneumonia. The sputa are generally catarrhal in character. The inflammation tends, in favorable cases, to terminate slowly, by lysis, possibly only after several weeks. When catarrhal pneumonia is the only complication, most cases end in recovery; but when it is but one of a number of complications, or occurs during a severe and abnormal attack of measles, the result is much more often fatal. Many cases of pulmonary tuberculosis after measles develop from an unresolved catarrhal pneumonia.

Lobar or croupous pneumonia is also a recognized complication of measles, but is of less grave import than the catarrhal form. It occurs abruptly, is not necessarily associated with extensive catarrh, and presents the characteristic symptoms. By many writers acute tuberculosis is described as a complication of measles. It should be classed among its sequelæ, though it doubtless very often dates back to the beginning of the attack. The intestinal catarrh that often becomes developed during measles sometimes becomes intensified, and to the diarrhœa there are added the symptoms of a more or less severe enteritis. Bloody, mucous stools, voided with tenesmus and the other signs of colitis, will at times be observed. These cases, however, usually end in recovery. It should be noted that in many of these cases the rash is not pronounced and sometimes fades, while the diarrhœa is very severe; so that a diagnosis of diarrhœa is often made, and the measles overlooked. Acute nephritis may also be a direct consequence of measles.[10] When convulsions appear during the course of measles after the development of the rash, they generally mark the supervention of some grave complication, and are thus of very evil augury. They may accompany pneumonia, enteritis, even meningitis. Inflammation of the middle ear of a catarrhal character, extending from the pharynx along the Eustachian tube, may occasion temporary deafness; or it may be intense, with severe pain, and followed by perforation of the tympanum. Permanent deafness may, but usually does not, result from this. Occasional and rare complications are gangrene of various parts, dropsy, various inflammations, hemorrhages, etc.

A much controverted question is that of the coexistence of measles with other eruptive fevers. Although Hebra denied the simultaneous presence of two of the exanthemata, many writers make positive assertions to the contrary. Thomas[11] says "measles can appear during the course of variola, scarlet fever, and varicella, and *vice versa*," and quotes Laverani as claiming that mumps attacked by preference patients suffering with measles, and Kesteren, who saw a girl attacked by measles while suffering from typhoid fever. Barthez and Rilliet also assert that two specific eruptive fevers may coexist. Blacke,[12] Steiner, Monti, Körber[13] report observations of the simultaneous existence of measles and other eruptive fevers, viz., scarlet fever, variola, and varicella. Traube,[14] Fischl,[15] Stiller, Trechmeister, and others report similar cases. There is, indeed, no reason why two specific morbid principles may not exert their peculiar pathogenic influences at the same time upon an individual.

* Pott reported as causes of death in 24 cases: pneumonia, 17 times; capillary bronchitis, 4 times; croup, 3 times (Jahrb. f. Heilk., vol. xiv., p. 331).

An abnormal course of different exanthemata, however, may be characterized by features of anomalous nature, and various lesions due to simple cutaneous irritation may complicate the eruptions. Erythematous, papular, vesicular, and pustular lesions may accompany any of these fevers, and may lead to errors of diagnosis. It is, therefore, not asking too much to insist that, before such coexistences can be definitely accepted, the evidence should include a sufficient number of cases of persons previously unaffected by either of the fevers in question, who have remained free from infection after subsequent exposure. Examples of one specific eruptive fever following another in near succession are sometimes observed; thus, Prior had a patient who developed scarlet fever November 18th, varicella December 2d, and measles December 13th.

SEQUELÆ.—These are either complications persisting after the subsidence of the exanthem, or they develop in consequence of some predisposition intensified or evoked by it. The power of resistance of the system is diminished by measles, and, under these circumstances, certain external influences may provoke morbid actions which, under more favorable conditions, they cannot. Thus, any affection attacking one lately recovered from measles must, strictly speaking, be called a sequela. As far as possible, however, it is better to restrict the term to those disorders in which the parts implicated are especially involved in measles, and which can be definitely attributed to its effects. In this sense, nearly all sequelæ of measles may be said to originate in the mucous membrane. Not infrequently, more or less severe chronic conjunctivitis, with obstinate blepharitis and hordeoli, follows measles. Keratitis and even keratomalacia, and other alterations in the orbit, may be occasionally observed. Catarrh of the middle and external ear, with sometimes persistent otorrhœa, is not very uncommon. These catarrhal inflammations may result in changes that produce more or less complete permanent deafness. Catarrhal and aphthous, even gangrenous, stomatitis sometimes follows measles. Whether by extension of these forms, or by spontaneous development, that, fortunately, rare buccal affection, *cancrum oris*, or *noma*, or gangrene of the mouth, has measles for its most frequent exciting cause (except, perhaps, mercurial ptyalism). Its course is usually a fatal one. Pharyngeal and laryngeal catarrh very commonly follow in the wake of measles. Usually, they are of brief duration. Ulcerative inflammations of these parts sometimes occur, and in the larynx may accompany or precede pulmonary phthisis. Bronchitis is the most common sequela of measles, carried over from the height of the attack. Its course is for the most part in the direction of health, but it too often becomes protracted, and leads to bronchopneumonia and pulmonary phthisis. Bronchopneumonia may develop after the effects of the measles seem to have disappeared, a slight cause serving to upset the balance of the lung, enfeebled by the antecedent attack. Croupous or lobar pneumonia may be similarly developed. Acute miliary tuberculosis may follow one of the affections just mentioned, or, developing at once, may pursue a rapidly fatal course. It is resulting pneumonia, catarrhal and croupous, and pulmonary phthisis, that make measles so formidable a disease, and a high death-rate in this disease is usually to be referred to one or other of these complications or sequelæ. Tuberculous disease in the bronchial and mesenteric glands may indirectly become sequelæ of measles, the latter following tuberculosis of the bowels. Enterocolitis, of very severe character, may sap the powers of life or greatly retard convalescence.

Measles may itself complicate other diseases, modifying and being modified by them. The coexistence of the acute eruptive fevers, and the influence of a pre-existing disease upon the course of measles, have already been considered. On the other hand, measles undoubtedly modifies the course of other diseases upon which it has become engrafted. Barthez and Rilliet have shown that a noxious influence is principally exerted over affections that are most frequently met with as true complications of measles. This disorder occurring during an attack of bronchitis, of lobular or lobar pneumonia, or of pulmonary tuberculosis, will almost invariably intensify them, the yielding inflammation will be rekindled, and new areas will become involved. Recrudescence of tubercle will scarcely fail to occur in tuberculous patients, and inflammations of mucous membranes will be made more active. Some other affections, however, seem to become ameliorated upon the supervention of measles. This may be real or only apparent. In the latter case the original disease will fade away during the attack, to return in full vigor after its disappearance. Examples of this may be seen in various cutaneous disorders, such as eczema, seborrhœa, psoriasis, etc., and in affections of different organs of the body. It has been asserted, again, that a number of diseases may be radically and permanently removed by a complicating attack of measles. Barthez and Rilliet have seen chorea, epilepsy, incontinence of urine, etc., disappear after an attack of measles.[16] Thomas has also had a similar experience.

Relapses and Reinfections.—There may be very rarely observed, in persons who have entirely recovered from measles, the sudden outbreak of an eruption exactly like that of measles in configuration, though hardly ever attaining more than a pale red coloration, and not accompanied by œdema of the skin or attaining a very wide distribution. Simultaneously, there will be very slight fever and catarrhal symptoms, not exceeding slight conjunctival hyperæmia and redness of the upper air passages. There may even be no fever at all. The appetite may not be affected, and the sense of well-being in no wise modified. The eruption is most abundant about the face, neck, and trunk, but may invade the general surface. It is exceedingly fugacious, hardly lasting more than twenty-four hours. These attacks usually occur within a few weeks after the original seizure,* and correspond closely to the descriptions of Rötheln, as given by certain writers. It is difficult to regard such attacks as other than relapses of measles. True reinfections, however, certainly do occur not so very rarely. Trujawsky[17] noted 14 cases of recurrent measles in 200 cases observed by himself. Six of these were in children less than ten years old; 6 were in children more than ten years old; 2 were in adults. The intervals between the attacks were from six months to seven years, the average being three years. Kassowitz has also reported cases of reinfection in which the attacks closely resembled Rötheln. They, however, could be traced to exposure to the contagion of measles, and themselves communicated measles to others. The failure to appreciate the frequency of relapses and recurrences of measles is undoubtedly a fruitful cause of error and discord among writers.

Of *second attacks*, as distinct from recurrences, Maizelis has gone through the literature, and gleaned only 106 cases, of which 103 were second attacks, and 3 represented a third attack (*Virchow's Archiv*, cxxxvii., p. 468).

ETIOLOGY.—Measles is an epidemic, contagious disease. All races of men are liable to it. The sexes are affected in almost equal proportion.† Although it nearly always attacks young persons, those of advanced age have no immunity beyond that conferred by infection in earlier life. Infants of tender age possess an immunity. "Jurgenssen (*Deutsches Archiv f. klin. Med.*) asserts that very young infants are 'immune,' and cites a recent series of observations of 41 exposed to measles. All over six months contracted the disease, while the 25 under five months were not affected" (*Archives of Pediatrics*, 1899, vol. xvi., p. 727). This immunity is not absolute, however, and a number of writers have reported observations of measles in new-born children. Beyond the first half-year of life this insusceptibility rapidly disappears, and

* Trujawsky records six such cases, in which the intermission was from six to fourteen days, with a medium duration of eleven and five-eighths days. In these cases, however, the second attack was of equal or greater severity than the first one.

† Of 276 cases noted by Pott, 147 were in girls and 129 in boys.

after the second year nearly all who are exposed to the contagion contract the disease. It is remarkable, however, that a few persons preserve an absolute immunity under any degree of exposure, and that numbers enjoy a temporary immunity, escaping many exposures unscathed, but finally yielding to the infectious influence. There is no reason to suppose that measles ever arises spontaneously. It is essentially contagious and is usually communicated by direct exposure to the emanations of a person sick of the disease, or through actual contact. The danger of contagion is proportionate to the propinquity of the contaminating influence, being greatest in the sick-room. It cannot be denied that measles may be spread by mediate contagion. In such cases the clothing probably becomes the disseminating agent. Such articles as have been used by the patient, the bed linen, even those things which have been used in the sick-room, very frequently communicate the disease. The discharges from the patients are not above suspicion in this regard. Except smallpox, measles is probably the most contagious of the exanthemata, and is communicable from the early prodromal stage until desquamation is completed. The infectious properties are probably most active during the prodromal stage. The great difficulty of identifying measles during this stage in great measure explains the rapid dissemination of the disease in schools, asylums, etc. The contagious properties continue throughout the stage of eruption, but speedily diminish with it, and probably become extinct during desquamation. Girard declares that quarantine is no longer needed after the eleventh day of the disease.* On the other hand, there are those who consider infection possible for several weeks after the disease has spent itself.

The contagion of measles exists in the blood [18] and in tears, in expired air, in nasal secretions, in sputa, and in epithelial and epidermic structures. Many efforts have been made to determine its exact nature. Its power of indefinite increase from the smallest possible beginnings seems to preclude a gaseous or liquid origin, and all probabilities favor the conception of a living organic substance, a *contagium vivum*, as the essential cause of measles. In 1862 Salisbury [19] declared that a peculiar fungus found in straw is the true measles germ and he claimed to have produced the disease by inoculating unprotected persons with this fungus. His researches, though important as among the first in the now widely worked field of parasitic pathogenesis, have never been confirmed. Coze and Feltz [20] and Keating [21] found micrococci in the blood, and Ransome, Braidwood, and Vacher, in the breath of patients with measles. In the sputa of patients with measles Eklund detected an organism $1.5\,\mu$ in diameter, united in numbers of two, three, five, to eight, or more, to form chaplets. These he also found in blood from the eruptive lesions and in the urine. He named this organism *torula morbillorum*.[22] A bacillus has also been found in the urine in measles by Le Bel. There have since been numerous reports of the discovery of organisms in the blood and secretions of measles patients; Canon and Pielicke found a bacillus, and Döhle parasitic protozoa, which were supposed to be the specific cause of measles. Other workers have made other reports, but these observations have differed too widely in their results to justify, at present, any conclusions regarding the specific nature of the contagious principle of measles; and it may be safely said that up to the present time the specific organism which causes measles is not known to us.

Though measles may be communicated through inoculation of blood, tears, saliva, etc., ordinary infection probably always occurs through the mucous membrane and its products, particularly that of the respiratory tract, the epithelia serving as contagium bearers.

In larger cities measles is probably endemic. In small towns and in rural districts, there are often long intervals during which it is not observed. It displays a pronounced tendency to prevail epidemically; indeed, epidemics recur with such apparent regularity, that a definite periodicity has been attributed to its recurrences. Closer observation, however, shows that no such periodicity exists, and that the extension of the disease depends upon two factors: "the time of importation of the morbid poison, and the number of persons susceptible to it." [23] Epidemics appear to be of greater severity in proportion to the infrequency of their occurrence. Localities where the disease does not prevail during prolonged intervals are said to experience its most intense types. A high rate of mortality is observed in races of men among whom measles prevails for the first time. This tendency has been supposed to be due to the action of the contagious virus operating upon the bodies of those who have not inherited through generations some capacity for resistance to its influence. There can be no doubt that different epidemics exhibit different types of severity or tendencies toward certain modifications or complications. The causes of this variability remain undiscovered. There is reason to believe that the great mortality following measles that prevails in a community for the first time, is in large measure due to the ignorance of the proper methods of treatment and general management of those affected. Just as bad hygienic conditions surely increase the mortality from measles, so will they the more readily under the circumstances now referred to. Accumulated evidence shows that even where the death rate is at the highest, the disease is still very amenable to proper treatment. Masterman writes: "At the beginning of the Brazilio-Paraguayan war, an epidemic of measles swept off nearly a fifth of the national army in three months, not from the severity of the disease, for I treated about fifty cases in private practice without losing one, but from want of shelter and of proper food." [24] Identical results were obtained under similar conditions in the Hudson's Bay Territory, the Fiji Islands, and elsewhere. No season exhibits any special influence upon the type of the epidemic. The mortality of winter and that of summer are about the same, but the disease is undoubtedly more prevalent during the colder than during the warmer months (Hirsch). In warm climates measles pursues a course equally favorable as in temperate regions, though there is a greater tendency toward intestinal complications. Local conditions of soil exert no influence in the etiology of the disease. The existence, in an individual, of chronic disease, especially of the respiratory mucous membrane, as bronchitis, pertussis, or tuberculosis, is said to predispose toward attacks of measles (Mayr).

Morbid Anatomy.—In fatal cases of measles the blood, after death, is of a bluish or brownish-red color, and is seldom completely coagulated. "It is sometimes thick and tarry, sometimes thin and of a cherry-red color" (Mayr). According to Mayr, the eruption of measles is characterized by the pouring out of exudation about the mouths of the hair sacs or sebaceous glands. On the other hand, G. Simon found no change in the hair sacs or sebaceous glands, nor even in the cutaneous papillæ. He found the epidermis not separated from the corium, but slightly swollen over the papillæ.[25] Neumann [26] concludes that the pathological changes in the skin are almost limited to the glands and vessels. In the superficial vascular area there is round-cell proliferation of the vessel walls, and especially in the papillary loops. The vessels themselves are dilated and hyperæmic. The sebaceous and sweat follicles are infiltrated with round cells. Cell infiltration of the *arrectores pilorum* is also observed. The cutis proper and the epidermis are almost unaffected. The changes in the mucous membranes are mostly those of ordinary catarrh. Traube has described a condition of the lungs observed by him in a number of children, who died during an epidemic of measles, which he calls "catarrhal interstitial pneumonia." In these the changes were very similar to those of the phthisis of adults, though the lower lobes were principally affected, and the process was at most only eight weeks old. In addition to evidences of catarrhal pneu-

* Hebra and Mayr and Munro assert that epidermis shed during the stadium desquamationis cannot communicate measles by inoculation.

monia, though the density of the lung could not be attributed to filling of the alveoli, many capillaries were empty. This condition was caused by a cell accumulation between the capillary wall and the lung epithelia. Traube thought that these cells were from the bronchial mucous glands, and that the entire process was an adenitis of these glands.

Prognosis.—Under favorable conditions a fatal termination of uncomplicated measles is most rare. Indeed, except in cases of malignant or "black" measles, it may be said never to occur. Meigs and Pepper reported not one death in two hundred and fifty-seven cases. The complications of measles are, however, so many, and of such frequent occurrence, that what would ordinarily otherwise be quite a trivial malady, becomes frequently a source of great danger, and is often followed by death. It is thus that measles presents quite a formidable death rate, death occurring most often during the second week—that is, after the course of normal measles would have been completed. The rate of mortality varies within wide limits. Ranke, in Munich, records a rate of 1.7 per cent. Of 844 cases Pott noted a mortality of 24, or 3 per cent. In St. Joseph's Children's Hospital, in Vienna, observations, extending over twenty years, showed a mortality from the disease of 8 per cent. On the other hand, a mortality of 44 per cent. was observed in the Hospice des Enfants Assistés, in Paris, during the years 1882 to 1885. In an epidemic in Sydney, reported by Carroll, in which there was a tendency toward malignancy, 54 of 900 measles cases perished. Fleischmann records 162 deaths in 740 cases; the minimum annual mortality was 2.3 per cent., the maximum rate was 31 per cent. His cases were classified as follows: Under one year, 35 cases, 18 deaths, 51 per cent.; from one to four years, 355 cases, 123 deaths, 34 per cent.; from five to eight years, 350 cases, 21 deaths, 6 per cent. Under five years there were 390 cases with 141 deaths, or 36 per cent. Every fifth child had pneumonia. Of these, 66 per cent. died. This high rate of mortality is due to the bad hygienic surroundings of children previous to their admission to hospital—conditions favoring the development of fatal inflammations. In malignant epidemics a much higher death-rate may be attained. At Lippe, in Hungary, in 1856, 50 per cent. of those attacked succumbed. In some epidemics there is developed a greater tendency toward dangerous complications than in others. The prognosis is always incomparably more favorable in patients whose surroundings accord with the best hygienic conditions. It has already been shown that the high death rate in certain races and localities is mainly attributable to want, exposure, foolhardiness, and not to especial malignity of the epidemic. The great mortality from measles in camps results from the necessarily exposed life of the victims. (See article on *Camp Diseases*, in Vol. II.) Under nearly all conditions the prognosis will depend upon the presence or absence of complications. Of these pneumonia most often destroys life. Lobar pneumonia, it is true, most often runs a favorable course, but catarrhal pneumonia is of much greater gravity, both immediately and remotely, as serving to initiate the processes leading to pulmonary tuberculosis. The extent and intensity of the pulmonary inflammation will serve as an index to the gravity of the case. Catarrhal croup is usually of not great importance, unless accompanied by œdema and spasm of the glottis, in which event death may ensue at once. Diphtheria, whether attacking the laryngeal and tracheal and pharyngeal mucous membrane, or any other portion of the respiratory or general mucous surface, is not very uncommon, and usually leads to a fatal issue. Convulsions occurring at the outset of the attack add but little gravity to the case, but occurring during the eruptive stage, or that of decline, they are most ominous, as denoting the occurrence of dangerous complications that commonly end in death. The development of gangrene or of tuberculosis augurs unfavorably for the patient, the first usually, the latter always. In certain cases, and in certain epidemics, there is a tendency toward inflammation of the bowels. This may develop into severe complications, and may prove fatal. The persistence of high fever beyond the usual period, the occurrence of delirium, of great rapidity and difficulty of respiration, of uncontrollable diarrhœa, and of convulsions, the sudden, premature recession of the rash, copious and repeated epistaxis—all increase the gravity of the situation. Measles occurring in a person already suffering from a serious disorder is very apt to terminate unfavorably. In delicate and feeble children, especially those whose respiratory organs are feeble; in persons exhausted and broken down by exposure, hunger, insufficient nourishment, prolonged marching, etc., measles may prove a most dangerous malady. Children of less than two years stand in more danger, when attacked, than those of greater age. Adults are more liable to fatal complications only when their conditions of life are especially unfavorable. Pregnancy is said to add greatly to the dangers of measles, and abortion may ensue. This statement is true only in a limited sense, and cannot be made of general application.

Treatment.—There is no specific treatment for measles. Its management will depend upon the type and the intensity of the attack, the nature and character of various symptoms and complications, the condition and surroundings of the patient. Very little need be done for a case of simple, uncomplicated measles. Most cases will do very well without any medicinal treatment whatever. Upon the appearance of prodromal symptoms, the child should be confined in a comfortable, well-ventilated room, free from draughts and dampness, at a temperature ranging from 69° to 70° F. during the colder months. Until the increasing severity of the symptoms destroys the desire to be up and about, the little patient need not be kept in bed. As the stage of eruption approaches, he will usually become so uncomfortable that he makes no objection to confinement in bed. During this period, a warm bath may allay the highly irritable condition of the nervous system so often observed. It also certainly favors the evolution of the eruption, if given toward the end of the third or during the fourth day. As the eruption develops most copiously about a locality where active hyperæmia has been artificially induced, as by a sinapism, so the general cutaneous hyperæmia induced by a hot bath will facilitate the evolution of the general eruption. The child may be immersed in a bath of from 90° to 100° F. for from three to five minutes, and when removed should be immediately wrapped in blankets, when, without the use of towels, it will soon become dry enough to be dressed in its night-dress. Warm drinks are, in the writer's opinion, a very useful agent in inducing gentle diaphoresis and in promoting the normal development of the eruption. Of these, hot lemonade and flaxseed tea are probably the most satisfactory. Though the temperature during the prodromal stage may already reach a high degree, it will very infrequently be necessary to employ cold bathing or other active antipyretic treatment at this period, or, indeed, at any period of normal measles. In ordinary cases the use of cold water externally, while probably not harmful, does not offer any especial advantages, in view of the usual natural tendency toward recovery. Although cold bathing is recommended by Thomas and others, with cold compresses and packs, whenever the temperature reaches 103° F., its employment can be considered important only in pronounced hyperpyrexia, a rare condition in measles. Should there be insomnia, restlessness, or premonitions of convulsions, one of the bromides will prove invaluable.

As the eruption begins to appear, all active medication may in most cases be neglected. Ordinary vigilance in controlling the movements and behavior of the patient, the administration of proper food, the maintenance of proper ventilation and temperature, will be all that is required in many cases. Very often, however, certain symptoms become unduly prominent and call for alleviation. The catarrhal symptoms, for example, may be distressing. Bronchitis may be severe and associated

with more or less troublesome cough, and even with the signs of spasmodic croup. An expectorant, with or without a bromide, will here prove of great assistance. Tartar emetic, which might otherwise be most serviceable, is here inadmissible on account of the diarrhœa so frequently present, which it might tend to aggravate. Squill, ipecac, senega, in various combination, in the ordinary popular cough syrups, may be given with or without small doses of opium. The vomiting, which is sometimes very annoying, may often be relieved by drop doses of dilute hydrocyanic acid, by crushed ice, by small quantities of brandy or champagne, or by any of the agents usually employed to control nausea and vomiting; or it will often quickly subside spontaneously, if the stomach be allowed to remain at rest until the desire for food has returned. The use of purgatives should be avoided, if possible, as, from the habitual tendency toward diarrhœa in measles, this may be suddenly aroused and become troublesome. When decided constipation is present, it is better to use enemata or the milder laxatives and purgatives, such as castor oil, rhubarb, or magnesia. When the eruption prematurely recedes, as from the occurrence of grave complications, it is useless to attempt to effect relief by efforts to recall it. Attention should be concentrated upon the intercurrent malady. Epistaxis is not apt to produce alarming consequences. The application of ice to the nose under these circumstances is not advisable. Compression of the facial and nasal arteries will often control the hemorrhage. Remedies ordinarily influencing epistaxis—ergot, turpentine, sulphuric acid—and the various appropriate external applications must be employed. The diet should be of the simplest character. Indeed, during the first few days, anorexia is so complete that all nourishment is refused. Since the course of the disease covers only a few days, this is of small importance, and the patient may be spared the importunities of over-anxious mothers and nurses. Milk, alone or with lime water, will often be acceptable, and may be given to the exclusion of everything else. Malignant measles will require the energetic administration of alcohol, carbonate of ammonia, and other stimulants. Under the use of such remedies a not insignificant proportion of these cases will recover.

Complications originating in the respiratory apparatus call for special treatment. Croup, whether catarrhal or diphtheritic, requires the same treatment as when primary. Capillary bronchitis, catarrhal and lobar pneumonia, should be treated in the ordinary manner, but with especial reference to their debilitating consequences as complications. Counter-irritation and warmth must be applied to the chest. The oiled-silk jacket here serves an excellent purpose. Poultices, when properly applied over the affected lung, serve admirably, but the dangers from improper management, the tendency to dampen the clothing and chill the surface when unskilfully used, may well deter one from their use. Expectorants containing the chloride and carbonate of ammonia, quinine, and such agents should now be employed, and especial attention paid to the diet, since the illness will now be protracted beyond the usual period. Diarrhœa does not often call for interference, as it will nearly always spontaneously cease after a day or two. A dose or two of opium, with subnitrate of bismuth, or a few grains of Dover's powder, or some drops of camphorated tincture of opium, will, in nearly all cases, prove effective. Catarrhal affections of the eye and ear require some attention. For most casfs the simple exclusion of light, or an eye wash of tepid water or milk, is all that is required. More severe inflammation requires especial treatment in accordance with its intensity. If the eyelids adhere, they must be separated by bathing in warm water and anointing with cold cream. The more severe disorders of the eye demand more energetic and special treatment. Aural inflammations spread from the buccal and nasal cavities, and often excite violent earache, which must be combated with warm opiated instillations through the external auditory canal. Atropine frequently acts charmingly in this condition, administered in two- or three-drop instillations of a two- or four-per-cent. solution. In the more severe cases of inflammation of the middle ear it will be found necessary freely to incise the membrana tympani. Hyperpyrexia will not occur in uncomplicated measles. When it occurs it should be treated upon general principles. Great relief is often afforded patients affected with measles by inunctions of camphorated oil, cold cream, or other fatty substance. Milton has highly extolled this method of treatment.

The patient should be kept in bed until all fever has subsided, and should not be permitted to leave his room until the disappearance of all symptoms, normal or abnormal. During convalescence appropriate tonics, ferruginous and otherwise, will prove valuable. Cod-liver oil should be administered to weakly persons or those who continue to have weak lungs after the attack.

Prophylaxis.—Measles is so intensely contagious that nearly all persons are attacked by it before adolescence. Unfortunate results so often follow the disease, however, that no one is justified in not placing unprotected persons beyond its influence. With measles the difficulty of accomplishing this is especially great, since it is already intensely contagious during the prodromal stage, when accurate diagnosis is often impossible. A person with measles should be separated from those who are unprotected, in a room into which only the attendants should be allowed to enter. Communication with the rest of the household should be as restricted as possible. All soiled linen should be soaked in disinfecting watery solutions and boiled separately. During the eruptive period the contagion will be much less disseminated if the whole surface of the body be systematically oiled once or twice daily. Isolation must be practised until all symptoms have subsided. Recent investigations make it very doubtful whether the disease can be communicated during desquamation. Some writers assert that a month should elapse before the patient be permitted to mingle with unprotected persons. Others (Girard) claim that quarantine is not necessary after the eleventh day of the disease. A hot bath administered at this time will remove nearly all desquamated epidermis, and along with it the contagious principle. Inoculation with the contagion-bearing particles from patients with measles has heretofore always educed unmodified measles, but it is not impossible that procedures may ultimately be discovered whereby prophylactic measures similar to those employed against smallpox, by inoculation, may be made available.

J. E. Atkinson.

Revised by *R. J. E. Scott.*

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MEAT INSPECTION.—Since the flesh of different quadrupeds, birds, and fishes constitutes an important part of the food supply of man, the importance of requiring that it should be furnished for this purpose in a sound and healthy condition is sufficiently apparent. For this purpose a system of inspection is necessary, in order that

healthy animals may be selected for slaughter, and that, after being killed, the meat may be submitted to such further inspection as may be deemed necessary.

While the inspection of meat is often conducted under the supervision of a sanitary authority, or by some other department, this inspection is usually entrusted to a different set of officials from those who are charged with the duty of inspecting other articles of food. All flesh foods, whether of meat, fowl, or fish, are rapidly perishable, and require different methods of inspection from those which apply to groceries and articles which deteriorate slowly.

The Slaughter of Animals.—The occupation of killing animals, dressing the meat, and preparing it for food should be under careful regulation, in order, *first,* that proper animals be selected for slaughter; *second,* that the slaughtering be performed in a humane and proper manner, and so that the food shall be in a clean and wholesome condition; and *third,* that the business may not become a nuisance to the neighborhood, as it is very liable to become under careless methods of operation.

In small towns and in rural districts such work is usually done in private establishments, but in the neighborhood of large cities and in densely settled districts it is desirable that it may be permitted only in one large establishment in which the several firms or individual butchers may work together, under the best sanitary regulations. Such an establishment is usually situated as a matter of convenience near a line of railway, where the cattle, sheep, and hogs may be received into yards, pens, or enclosures, to await the time of slaughter. By this means the work of supervision may be readily performed under a competent authority. The cleanly and careful methods conducted at the great abattoirs of Berlin, Paris, Munich, and other European cities are in strong contrast with the old methods of work once conducted in the private establishments of the same cities.

Laws and regulations relating to the slaughtering of animals have existed for centuries. From the days of Moses down to the present, different nations have maintained systems of slaughtering and meat inspection of greater or less efficiency.

In England during the reign of Henry VIII., slaughtering was forbidden in walled cities, and in France as early as 1570 slaughtering was limited to places outside the city limits, and in the neighborhood of water-courses. By a law of 1815 slaughter-houses in France could be established only at a certain distance from dwellings in places of more than ten thousand inhabitants, and by a later law of 1838 this requirement was extended to all cities. The five model slaughter-houses of Paris erected about 1807 were replaced by a central establishment in 1867.

At present all meat, whether sold in slaughter-houses, markets, or butcher shops, in Paris must be submitted to inspection. The same obligation is in force for the offal and the products of manufacture. This inspection must be made in every shop at least twice a month. The inspectors of meat are also entrusted with the examination of poultry, game, and fish.

A large number of private slaughter-houses were built in the suburbs of Paris in consequence of these vigorous measures enforced in the city. These have been placed under the supervision of ten special inspectors since 1883. Their jurisdiction extends over the whole of the department of the Seine (Palmberg).

In several foreign countries, according to Schwarz in his work on public slaughter-houses, there is as yet no obligatory meat inspection by public officials.

In Russia until 1882 there was no public slaughterhouse. In that year one was established at St. Petersburg, and in 1894 there were still only ten in the whole empire. Those of Warsaw are owned by private citizens.

Schwarz enumerates a list of five hundred and seventy-three municipalities in the German empire in each of which provision is made for an establishment for slaughtering animals. The population of these, according to the last census, varied from as low as one thousand or even less to one and one-half millions in Berlin.

Inspection of Meat in England.—The Public Health Act of 1875 provides as follows:

"116. Any medical officer of health or inspector of nuisances may at all reasonable times inspect and examine any animal, carcass, meat, poultry, game, flesh, fish, fruit, vegetables, corn, bread, flour, or milk exposed for sale, or deposited in any place for the purpose of sale, or of preparation for sale, and intended for the food of man, the proof that the same was not exposed or deposited for any such purpose, or was not intended for the food of man, resting with the party charged; and if any such animal, carcass, meat, poultry, game, flesh, fish, fruit, vegetables, corn, bread, flour, or milk appears to such medical officer or inspector to be diseased or unsound or unwholesome, or unfit for the food of man, he may seize and carry away the same himself or by an assistant, in order to have the same dealt with by a justice.

"117. If it appears to the justice that any animal, carcass, meat, poultry, game, flesh, fish, fruit, vegetables, corn, bread, flour, or milk so seized is diseased, or unsound or unwholesome or unfit for the food of man, he shall condemn the same, and order it to be destroyed, or so disposed of as to prevent it from being exposed for sale, or used for the food of man; and the person to whom the same belongs, or did belong at the time of exposure for sale, or in whose possession or on whose premises the same was found, shall be liable to a penalty not exceeding £20, for every animal, carcass, or fish, or piece of meat, flesh, or fish or any poultry or game, or for the parcel of fruit, vegetables, corn, bread, or flour, or for the milk so condemned, or at the discretion of the justice, without the infliction of a fine, to imprisonment for a term of not more than three months.

"The justice who, under this section, is empowered to convict the offender, may be either the justice who may have ordered the article to be disposed of or destroyed, or any other justice having jurisdiction in the place."

Section 118 imposes a penalty of £5 upon any one who obstructs or hinders an officer, in the performance of the foregoing duties.

Section 119 provides for granting a search warrant to enable an officer to seize and carry away any of these articles that may be concealed, with a further penalty of £20 for obstruction.

Germany.—The German meat laws contain in brief the following provisions:

1. Common decrees relating to the introduction of requirements as to slaughtering.
2. Regulations for the examination of cattle slaughtered in slaughter-houses.
3. Police regulations relating to the use of city slaughter-houses.
4. Police regulations relative to the examination of pork for trichinæ.
5. Regulations for the examination of fresh meat brought in from abroad.
6. Police regulations relative to the sale of inferior meat at the "Freibank."
7. Regulations as to the sale of horse-flesh.

These laws, regulations, and ordinances are too lengthy and minute to be quoted in full. They consist of a series of enactments extending from 1850 to the present. The laws relating to pork inspection have been the subject of more discussion than any other topic, since they were, for many years, aimed at the exclusion of American pork. That of 1880 prohibited the importation of American sausage and chopped meat, and that of 1883 excluded all American pork. By a later circular of 1891 American pork was again admitted to Germany. Notwithstanding the large army of inspectors of pork maintained in Germany there were reported in that country 6,329 cases of trichinosis among its population from 1881 to 1898, and 318 of these proved fatal, and these were all due to the eating of German pork. On the other hand, according

to Dr. Stiles,* "a compilation of all the evidence fails to show that a single case of trichinosis has been traced to the 200,000,000 pounds of American pork exported to Germany in the fiscal years 1892–98." These were the years in which American pork was admitted to that country. The unusual prevalence of trichinosis among the German population is due to the extremely unsanitary custom, so common in that country, of eating raw or half-cooked pork, ham, or sausages.

Austria.—The sale of the flesh of uninspected animals is punishable by law. Inspection is performed by special officials who superintend the slaughter of animals whose flesh is exposed for sale. These animals are examined before and after slaughter. Those which come from a distance are placed under inspection for ten days before they are killed. A special course of instruction is provided for inspectors of meat in the veterinary schools.

Sweden.—In Sweden, or at least in Stockholm, bureaus for meat inspection exist under the charge of veterinary surgeons. Inspection is not compulsory except for pork. Tradesmen find it to their advantage to have their meat inspected, since such meat commands a higher price. If trichinæ are found in pork upon examination, the meat is confiscated and destroyed.

In 1866 a demand arose for the improvement of the modes of slaughtering in the town of Brighton, then a suburb of Boston, where most of the meat supply of the city was prepared for the market. A large number of butchers conducted their work in separate establishments, and, as usually happens under such conditions, many of them proved to be extremely offensive to the surrounding neighborhood. Dr. H. G. Clark, in a report to the selectmen of Brighton, condemned the methods of slaughter in the strongest terms and said: "Any description of the slaughter-houses must fall far short of the perfectly disgusting reality, which can only be appreciated by a personal inspection."

Upon the organization of the State Board of Health in 1869 the board took up the subject in earnest, and recommended the construction of an abattoir with the following requirements:

1. A pavement of stone, or of some material impervious to blood.
2. An abundant supply of water.
3. Complete drainage.
4. Vats for the "rendering" of fat and offal on the spot, before putrefaction can attack them.
5. The means for converting blood into blood albumen.

It was also claimed that the sanitary advantages of such a system would be:

1. The removal of existing offensive odors.
2. The removal of slaughter-house pork from the markets.
3. The ready inspection of meat, thus insuring the rejection of that which is unfit for food.

The following economic advantages were also claimed:

1. Diminished liability of having meat spoiled by exposure to the emanations from the putrid pig-pens.
2. The value of the blood, which would be saved and utilized.
3. The savings which must always accompany order, system, the division of labor, the avoidance of transportation, and the doing any business on a large scale.
4. The greatly increased value of land in the neighborhood of existing slaughter-houses.

Experience has shown that all these claims have been fully realized. The result of the agitation was the enactment of a law in 1870 providing for the incorporation of an organization for the construction of an abattoir, and requiring that all persons conducting the business of slaughtering within certain prescribed limits (within six miles of Faneuil Hall Market in Boston) should carry on such business upon the premises of the abattoir.

A further movement in the following year secured the enactment of a general law regulating the business of slaughtering and other noxious and offensive trades throughout the State. Under this law of 1871 action was taken against twenty-three parties, resulting in the promulgation of orders requiring seventeen of these parties to "cease and desist" from the business of slaughtering, rendering, etc., or to discontinue certain processes of work.

The Brighton abattoir was completed in June, 1873, and during the following six months 14,194 cattle, 2,700 calves, and 150,000 sheep had been slaughtered in it, or about one-half of the meat supply of Boston for that length of time.*

Modes of Slaughter.—The principal modes of slaughter are practically two in number.

1. The stunning of the animal, or rendering it insensible either by a blow on the head with an iron hammer, by driving a bolt into the brain, or by shooting through the forehead.
2. Direct bleeding by severing the carotids, and other blood-vessels of the neck (the so-called Jewish mode).

The different societies for the prevention of cruelty to animals advocate the former. Dr. Dembo recommends the latter, claiming that death ensues in three to five seconds.† He also states that the quantity of blood remaining in the meat by the former method increases its weight to the butcher's advantage and the consumer's loss. "A government that has to victual an army of a half million men would be cheated by its contractors to the extent of $125,000 per year."

Meat Inspection.—The principal kinds of meat eaten by mankind are the meat of cattle, sheep, swine, poultry, and wild game. The importance of meat as an article of food is due to the relatively large quantity and easily digestible form of the albumen which it contains. In addition it also has fat and salts, but has no carbohydrates. The good quality, savory taste, and nutritive value of meat depend on the class of animal, age, sex, and kind of feeding, as well as on the part of the body from which it is taken. That of young animals is usually soft, tender, and light red in color. That of older animals is poorer in fat, tough, and darker in color. By certain kinds of fodder the proportion of fat is increased, and the water in the meat is reduced. The flesh of calves and fowls (usually called "white meat") as well as venison and tender, lean beef, are easily digested, while other kinds of meat are digested with greater difficulty, especially very fat and sinewy meat. The heart, tongue, liver, kidneys, and brains are digested without great difficulty.

The eating of those portions or organs of animals which are specially subject to disease, such as the lungs of cattle and the fattened and diseased livers of geese, should be condemned.

Objects of Meat Inspection.—The chief objects of meat inspection are the exclusion of meat which is unfit for food, on account: (1) of the presence of diseases dangerous to man, and (2) on account of decay, putridity, or such causes as may render it unfit for food.

Examination of Meat. Color.—The normal color of sound flesh varies with its origin, ranging from white, as in many fish, to dark-purple as in horse flesh.

Abnormal Colorations. Melanosis.—Sometimes this is only local. The black pigment is probably a derivative of hæmoglobin. In Germany such meat is sold at a low price.

White Flesh.—This is found normally in certain animals. Sometimes the flesh of a cow or ox does not acquire the usual amount of hæmoglobin, and has the appearance of veal. White flesh is occasionally found in certain diseases, such as the anæmia of dropsy, and is probably caused by insufficient oxidation of the blood.

Yellow flesh is sometimes due to certain colored foods, and in disease may be caused by absorption of bile.

Dark Purple.—This color may indicate that the animal has suffered from acute fever, and has been met in ani-

* "Trichinosis in Germany." Department of Agriculture, Washington, 1901.

* Fifth report of the State Board of Health of Massachusetts, p. 155.
† "The Jewish Method of Slaughter," London, 1894, p. 4.

mals which have died of rinderpest and tuberculosis. It may also be due to insufficient bleeding after death in animals which have died from natural causes.

Dark Reddish-Brown.—This color is due to imperfect oxidation of the blood, and is seen in animals which have been drowned, or suffocated in smoke. It is also occasionally seen in the flesh of overdriven or hunted animals.

Green or Violet.—This color is due to the beginning of putrefaction, or to the diffusion of vegetable coloring matter through the walls of the stomach after death.

The Consistency of Meat.—The consistency of flesh food is an index of its soundness. Good meat is firm, while unsound meat is usually flabby and exudes moisture. Coarse-grained meat which cannot be cut evenly is inferior to fine-grained meat.

Lehmann has devised an ingenious apparatus for determining the degree of toughness of meat (*Zeitschrift Fleisch- u. Milch-Hyg.*, 1898, viii., p. 32). It consists of a balance with arms of different lengths, the shorter being made on the plan of a pair of scissors with one fixed blade. The weights are placed in the pan of the longer arm, and the force required to cut through a layer of the meat 1 cm. thick is expressed in grams. By this means Lehmann found that the skin muscle of beef is two and one-half times as tough as the fillet. Flesh which contains much collagenous tissue becomes more tender on boiling, while meat which contains but little remains about the same as before boiling.

Lehmann obtained the following results:

Force Required for Division Expressed in Grams.

	Raw.	Boiled.
Fillet of beef	83.4	84.0
Skin muscle of beef	236.4	88.8
Heart	104	88
Liver, ox	42	8
Liver, calf	35	6.6
Kidneys	40	24
Brain	7	2.4

The Odor of Meat.—Aside from ordinary rough inspection by the sense of smell, which is much more acutely developed in some persons than in others, the odor may also be observed by boiling fragments of flesh with water, and also by mixing the flesh with dilute sulphuric acid, distilling about one-fourth of the liquid, and noting the smell of the distillate; it may be:

1. The normal odor, characteristic of the animal.
2. The characteristic odor intensified, as in the case of uncastrated male animals. This is more marked with the flesh of the he-goat and boar than with that of the ram and bull.
3. An abnormal odor due to the substances eaten by the animal.
4. An odor due to chemical alteration or decomposition, as, for example, that of the volatile products formed during the putrefaction of flesh.
5. An odor of foreign substances, chloride of lime, carbolic acid, etc.

The Diseases of Animals Used as Food.—Animals should be inspected within twenty-four hours before slaughter. The principal diseases for which the inspecting officer should watch are:

Among cattle, 1. Pleuropneumonia; this disease is not easily recognized at first. The temperature soon rises to 104° or 105° F. and the animal refuses food. A short, dry cough develops and the breathing becomes labored and painful.

2. Cattle plague (Rinderpest). Recognized by early prostration, shivering, discharge from nose, eyes and mouth, cessation of rumination, abdominal pain and scouring.

3. *Anthrax.* This may be general or localized. If boils, pustules, or carbuncles form they are recognized at once. The peculiar organism of anthrax may be detected in the blood.

4. *Tuberculosis.* This disease has attracted more attention than any other, but the question whether it may be transmitted from animals to man does not yet appear to be fully settled. In cattle it may be acute or chronic. At first there may be no emaciation nor diminution of the milk; later, emaciation supervenes, and there are loss of appetite, shortness of breath, and cough, and these become intensified.

Three royal commissions have reported in England upon the subject of bovine tuberculosis, those of 1890, 1895, and 1898. The conclusions of the latter commission (1898), so far as meat is concerned, were as follows:

"We recommend that the Local Government Board be empowered to issue instructions from time to time for the guidance of meat inspectors, prescribing the degree of tuberculous disease which, in the opinion of the board, should cause a carcass, or part thereof, to be seized.

"Pending the issue of such instructions, we are of the opinion that the following principles should be observed in the inspection of tuberculous carcasses of cattle:

"*a.* When there is miliary tuberculosis of both lungs. "*b.* When tuberculous lesions are present on the pleura and peritoneum. "*c.* When tuberculous lesions are present in the muscular system, or in the lymphatic glands, embedded in or between the muscles. "*d.* When tuberculous lesions exist in any part of an emaciated carcass.	The entire carcass and all the organs *may be* seized.
"*a.* When the lesions are confined to the lungs, and the thoracic lymphatic glands. "*b.* When the lesions are confined to the liver. "*c.* When the lesions are confined to the pharyngeal lymphatic glands. "*d.* When the lesions are confined to any combination of the foregoing, but are collectively small in extent.	The carcass, if otherwise healthy, shall not be condemned, but every part of it containing tuberculous lesions *shall be* seized.

"In view of the greater tendency to generalization of tuberculosis of the pig, we consider that the presence of tubercular deposit in any degree should involve seizure of the whole carcass and of the organs. In respect of foreign dead meat, seizure shall ensue in every case where the pleura have been 'stripped.'"

5. *Actinomycosis.* Attacks by preference the lower jaw and tongue, also the lungs and bones. It leads to general malnutrition and is sometimes fatal.

6. *Texas Cattle Fever.* In this disease there is intense fever with a temperature of from 105° to 110° F., with great weakness and prostration. The ears and head droop, the hind legs are advanced under the body, giving the animal a characteristic attitude. The urine becomes deep colored, like undiluted venous blood. The liver and spleen are congested and enlarged, the kidneys also are congested and show numerous blood extravasations.

Sheep. In addition to the foregoing diseases sheep are subject to splenic apoplexy, or "braxy." The meat in this disease is dark and sometimes dropsical, and the weight of the spleen is increased, often to double its normal weight. When attacked the animal staggers, stretches out its head, and breathes rapidly.

Sheeppox is known by the high fever, especially in the pustular stage, by the flea-bitten appearance of the skin in the early stage, and by the rapid appearance of nodules or vesicles.

Liver flukes are large parasites, an inch or more in length, and about three-eighths of an inch wide, which are found in the bile ducts of the liver, occasioning the disease known as the "rot." The principal symptoms are

sluggishness, followed by wasting and pallor of the mucous membrane, diarrhœa, yellowness of the eyes, falling of the hair, and dropsical swellings.

Swine. The principal parasitic diseases of the hog which unfit the meat for use as food are the "measles" and trichinosis. The former is known by the appearance of small, egg-shaped bladders about one-quarter of an inch in length containing the larvæ known as cysticerci, which when eaten uncooked or nearly raw become tapeworms in human beings. In live hogs these little bladders may occasionally be seen beneath the tongue, or in the loose folds near the tail. Perroncito found that a temperature of 50° C. (122° F.) maintained for a minute or more destroyed the vitality of cysticerci.

Trichinosis. Trichinæ are found chiefly in the muscular tissue, though occasionally in the fat of swine. They are usually most abundant in the pillars of the diaphragm. With a low magnifying power they may be easily detected in a thin shaving of infected pork, either encysted and coiled up in the cyst or free and living. Swine affected with this disease do not necessarily present noticeable symptoms during life. Examinations made by the State Board of Health of Massachusetts showed that swine fed upon city offal, or garbage, and especially upon the entrails of infected animals, were far more subject to the disease than those which are fed upon healthy food (grain, vegetables, or cooked food).

This disease has assumed an international importance, as shown in a recently published pamphlet of the United States Department of Agriculture entitled "Trichinosis in Germany."

The danger to man lies in the eating of raw or imperfectly cooked pork, ham, bacon, sausages, or other meat of swine, and consequently the thorough cooking of such meat will prevent its occurrence.

Hog Cholera. Animals affected with this disease have fever, shivering, unwillingness to move, loss of appetite, a temperature of 106° to 107° F. They appear stupid and dull, and hide in the litter. The bowels may at first be constipated, but later there is usually a liquid and fetid diarrhœa, exhausting and persistent. There is rapid loss of flesh. The animal grows weak, stands with arched back and abdomen drawn up, and walks with tottering gait.

Horse Flesh. A law was enacted in England in 1889 which defines horse flesh to be such flesh cooked or uncooked, alone or mixed with other substances, and includes the flesh of asses and mules. This act provides that the flesh of horses, asses, or mules must not be sold or kept for sale as human food, except in a shop or stall over which is placed conspicuously, in legible characters four inches long, a statement that horse flesh is sold there. It also prohibits the sale of horse flesh for human food to any purchaser asking for other meat, or for a compound article not usually made of horse flesh.

There is no evidence that sound, healthy horse flesh is less wholesome than that of beef.

The Use of Preservatives.—For the purpose of preserving fresh meat, fish, canned meats, hams, and sausages various chemical agents are employed, and the tendency to use these substances appears to be increasing. Various opinions are expressed as to the propriety of using such agents as salicylic and boric acid and formaldehyde. Although the harm arising from the constant use of such substances may be less than that which might arise from using meat in a state of incipient putrefaction, the possibility still remains of harmful effect to the consumer from the frequent use of preservatives in meat and other kinds of food. The substances in most common use for this purpose are boric acid and borax, salicylic acid, sulphites, and formalin. The following are the recommendations of the recent British Parliamentary Commission upon this subject. This report was made to Parliament in 1901:

1. That the use of formaldehyde or formalin, or preparations thereof, in food or drinks, be absolutely prohibited, and that salicylic acid be not used in a greater proportion than one grain per pint in liquid food, and one grain per pound in solid food. Its presence in all cases to be declared.

2. That the use of any preservative or coloring matter whatever in milk offered for sale in the United Kingdom be constituted an offence under the Sale of Food and Drug Acts.

3. That the only preservative which it shall be lawful to use in cream be boric acid or mixtures of boric acid and borax, and in amount not exceeding 0.25 per cent., expressed as boric acid, the amount of such preservative to be notified upon the vessel by a label.

4. That the only preservative to be used in butter and margarin be boric acid or mixtures of boric acid and borax, to be used in proportions not exceeding 0.5 per cent., expressed as boric acid.

5. That in the case of all dietetic preparations intended for the use of invalids or infants chemical preservatives of all kinds be prohibited.

6. That the use of copper salts in the so-called greening of preserved foods be prohibited.

7. That means be provided, either by the establishment of a separate court of reference, or by the imposition of more direct obligation on the Local Government Board, to exercise supervision over the use of preservatives and coloring matters in foods, and to prepare schedules of such as may be considered inimical to the public health.

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MEDIASTINUM, DISEASES OF THE.—The mediastinum is a space left in the median portion of the chest by the non-approximation of the pleuræ; it is bounded in front by the sternum, behind by the vertebral column, and on either side by the pleural surfaces. It may be divided into two parts, the anterior mediastinum, including the space in front of the pericardium and trachea, and the posterior mediastinum, including the space behind these. The structures found in the anterior mediastinum are: the heart surrounded by the pericardium, the ascending aorta and the lower parts of its branches, the lower part of the superior vena cava, the greater azygos vein, the innominate veins, the pulmonary artery dividing into its two branches, the right and left pulmonary veins, the bifurcation of the trachea and the two bronchi, the phrenic nerves, the anterior mediastinal lymph glands, the bronchial lymph glands, and, in early life, the thymus gland.

The posterior mediastinum contains: the descending aorta, the greater and lesser azygos veins, the pneumogastric and splanchnic nerves, the œsophagus, the thoracic duct, and the posterior mediastinal lymph glands. In considering the diseases of the mediastinum, however, the heart and pericardium are not included, nor are the trachea, bronchi, œsophagus, blood-vessels, and nerves, except so far as they are secondarily involved. The structures in this region which chiefly concern us are the

thymus gland, and the lymph glands and vessels which are subject to degenerative changes, infection, hyperplasia, hemorrhage, and tumor formation.

THYMUS GLAND.—This is an organ of intra-uterine life and childhood, reaching its greatest development during the second year and from that time on undergoing a slow atrophy and fatty degeneration until it is finally transposed into a mass of fat, the so-called "thymic fat organ" (Waldeyer). The thymus arises from the entodermal layer of the third gill clefts, each of which sends down a tubular prolongation of epithelial cells on one side of the trachea; these tubes (which have a narrow lumen and a thick epithelial covering) then approach each other and coalesce in front of the trachea to form a solid flat organ. From the mesoderm a vascular stroma grows into the epithelial mass, dividing it into lobes and lobules, and forming a capsule around it. Small, round connective-tissue cells accumulate within the stroma and form follicles of lymphoid tissue, increasing at the expense of the epithelial cells, which are finally reduced to scattered islands of concentrically arranged squamous cells—the so-called Hassall's corpuscles. These corpuscles persist and may even be found after involution of the organ, in the thymic fat. Involution takes place by disappearance of the lymphoid cells and their replacement by epithelial cells derived apparently from the endothelium of the perivascular lymph spaces, which become filled with fat. The thymic fat organ containing Hassall's corpuscles can be found even in old age. It is important to remember that the capsule of the thymus gland is rich in lymph glands.

The thymus grows rapidly during intra-uterine life, attaining its greatest dimensions between the first and second years of infancy. At this time it consists of two flat lobes joined by delicate vascular connective tissue; it is soft and pinkish and has an abundant milky white secretion, which has often been mistaken for pus. Lying directly upon the trachea, it extends from 1 cm. above the sternum down to the lower border of the fourth costal cartilage, being in relation above with the thyroid gland and below with the pericardium, the arch of the aorta, the pulmonary artery, the superior vena cava, and both innominate veins, with all of which it is connected by delicate bands of fibrous tissue rich in lymph glands. As to the physiology of this organ, whether it is concerned in blood formation or in the development of bone or of the nervous system, we know practically nothing, and extirpation experimentally performed upon animals has as yet thrown no light on the question.

The dimensions of the thymus gland are very variable even within normal limitations, and this fact has given rise to great confusion as to what size the gland must attain in order to be regarded as abnormal. Friedleben's classical work ("Die Physiologie der Thymusdrüse," Frankfort a. M., 1858) remains to this day the source of most of our knowledge on this subject. Here are his statistics as to the weight of the gland at different ages: Three to five months intra-uterine life, 0.3 gm.; six to seven months intra-uterine life, 2.4 gm.; eight months intra-uterine life, 8.4 gm.; at term (measuring 6 by 4 cm.), 14.3 gm.; one to nine months after birth (this is the period of greatest secretory activity), 20.7 gm; ninth month to second year, 27.3 gm.; second year to fifteenth year, 27.0 gm.; fifteenth year to twenty-fifth year, 22.1 gm.; twenty-fifth year to thirty-fifth year, 3.1 gm.

As can be seen by these figures the atrophy of the thymus is not nearly so rapid as is usually supposed, beginning practically after the twentieth year instead of at puberty, as is so often stated. Vierordt, for instance, gives the weight at birth as 24 gm., reaching 26 gm. at the end of the second year and remaining at this weight until puberty, when atrophy begins and is complete by the twentieth year. But the figures given by Friedleben, depending as they do upon an enormous number of examinations, are generally accepted. Individual variations in size undoubtedly occur, and the nutrition of the child is a very important factor, as the thymus is invariably atrophied in marantic children; indeed Seydel considers this atrophy the most indisputable proof of death from inanition.

This variability in size makes it a matter of much difficulty to decide in a given case whether, in the absence of other pathological findings, a thymus gland exceeding the average in size may be regarded as the cause of death. The so-called "asthma thymicum" is absolutely denied by some authorities, by others regarded as a not very uncommon cause of death in childhood, and a rare cause in adult life. Statistics founded on the cases reported prior to Friedleben's work prove little and many cases since his time are open to objections; but even after a most searching review there remain a number of indisputable instances of sudden death, from strangulation, of healthy infants and children in whom the autopsy revealed no abnormality except a much enlarged thymus gland. Such are the four cases reported by Pott, in which all the patients died with symptoms of suffocation within two minutes after the attempt of the physician to insert a spatula into the mouth; the two cases of Grawitz; the case of Clar, who after performing tracheotomy on a child, was unable to insert the tube because of the narrowing of the trachea from pressure of an enlarged thymus.

Granting that the enlargement of this gland may cause death by suffocation, it remains to be explained how such a result is brought about. A direct mechanical compression of the trachea, evidenced by a flattening perceptible after death, has been shown only in the cases of Somma, of Benecke, and of Barach. More probable seems compression of the thin-walled, collapsible superior vena cava with its branches, which might be gradually compressed for some time without giving rise to symptoms. Hasse gives this explanation.

Another possibility is pressure on the recurrentes or vagi, in which case asthma thymicum would be spasma glottidis set up reflexly from the thymus. All of these explanations are open to the objection of not accounting for the suddenness of the symptoms. The puzzling fact is that death takes place apparently by suffocation within a few moments. If the large thymus is the cause, then it acts quite differently from other tumors by inducing, not a gradually increasing dyspnœa, but a spasma glottidis. Pott endeavors to explain it as due to a sudden bending back of the child's head, increasing the pressure; but in that case the child's instinct would be sufficient to cause it to right the position of the head at once. More plausible, but still unproved, is the theory of gradually increasing enlargement which finally reaches the fatal point, an enlargement which would seem not improbable in rachitic or lymphatic children, but would be hard to explain in the healthy; or it may be that the thymus is subject to great vascular engorgement and that the increase in size to the point of fatal compression is actually as sudden as are the resulting symptoms, the contraction of the vessels after death preventing the condition from being recognized. Jacobi considers this possible. Unfortunately for this theory the thymus is not a very vascular organ.

Cohnheim first pointed out the fact that most of the children who die of spasma glottidis are rachitic. He reported one such case, in a rachitic child with one lung partially atelectatic as a result of the pressure of a large thymus. The relation between spasma glottidis and rachitis has been emphasized by Jacobi also, but he is inclined to attribute death in these cases not to direct pressure but to the cerebral and meningeal hyperæmia and effusion resulting from the rachitis. In proof of this he points out the increase of thymic asthma in this country as coincident with the increase of rachitic children following the enormous immigration from the poor, ill-nourished classes of Europe. He is able to account in this way for all the cases of death from laryngismus stridulus which have come under his notice, except one in which the thymus weighed 410 gm. and extended from the thyroid gland down to and covering the pericardium.

Persistent thymus gland in middle life and old age has been given as a possible cause of death in some obscure

cases, but in most of these other possible causes were not eliminated. Among the least doubtful may be mentioned those of Bruce (1867), Jacobi (1883), and Glück (1894). Complete absence of the thymus was first observed by Bischoff in a still-born child otherwise perfectly normal; later on, four cases were reported by Friedleben. It is commonly absent in monstrosities, especially anencephalic monsters.

Inflammation of the thymus, with or without pus formation, is not common and many of the instances of thymic abscesses in the literature may have been simply normal glands, the milky secretion of which was mistaken for pus. Undoubted cases are those of Wittich, Hennig, Demmé, and Pürkhardt; that of the last-named was a thymic abscess which broke into the trachea. Jacobi found changes in the thymus in two cases of diphtheria, changes which from his description were evidently focal necroses. Simple inflammation by extension from a pleurisy or pericarditis has been also found. Small hemorrhages are often found in the thymus gland in healthy children who have died during or shortly after delivery. Friedleben reports one case of extensive hemorrhage in the thymus and elsewhere, the child dying suddenly while asleep, without spasm. Malnutrition was marked in this case. Péan's case was one of purpura hæmorrhagica in an eleven-year-old child; the thymus was very large and soft, resembling the spleen, and full of hemorrhages. Hoffmann thinks that this was probably a lymphoma with hemorrhages.

Cysts in the thymus have been described and have been accounted for by œdema, by softening of blood clots, or by softening of gummata. Tuberculosis is not rare, but is usually secondary to tuberculosis of the bronchial glands, although Demmé has reported a large tuberculous thymus in a child of six weeks with no tuberculosis in any other organ. Syphilis of the thymus gives rise to various lesions: to foci of suppuration (Dubois, Wells, Hanfsted, Mervis), or cysts (Jacobi, Hoffman), or syphilitic endarteritis with induration (Fürth, Jacobi), or gumma (Jacobi).

Tumors of the thymus will be described in the section on mediastinal tumors in general.

DISEASES OF THE BRONCHIAL AND MEDIASTINAL GLANDS.—Barété's division of the bronchial glands ("De l'adénopathie trachéobronchique," Thèse de Paris, 1875), which is very generally accepted, is the following:

1. Right pretracheobronchial group in relation with the superior vena cava, the arch of the aorta, vagi, trachea, and right bronchus.
2. Left pretracheobronchial group, at the angle of the bifurcation of the trachea and along the left bronchus. This is less large and important than the right group.
3. Intertracheobronchial group in the space below the bifurcation of the trachea between the main bronchi.
4. Peribronchial group, accompanying the bronchi.

In addition there is the small group of anterior mediastinal glands in the areolar tissue in front of the pericardium and the posterior mediastinal glands, which run in a chain in the posterior mediastinum parallel with the œsophagus.

Simple, non-infectious hyperplasia of the bronchial glands has been described by Thomas and by Biedert. The symptoms are the same as in tuberculous infection of these glands, and the authors in question base their belief in the non-infectious nature of the process on the apparent recovery of their cases. On the other hand, many authorities believe that all enlargements of the bronchial lymph glands are tuberculous; others distinguish a purely suppurative form which may end in resolution or in abscess formation, but which is not primarily or secondarily tuberculous. In every case of bronchitis the glands are probably involved in the inflammation, but usually this subsides; if, however, it goes on to enlargement of the gland by chronic productive inflammation we have the symptoms due to pressure or contraction, which will be considered under tuberculous glands. Measles, grippe, pneumonia, whooping-cough may give rise to such hyperplasia; indeed, Mussy believes that the pressure of these enlarged glands is the true anatomical cause of the attacks of coughing in whooping-cough. Aside from the possibility of chronic hyperplasia there is that of abscess formation, and it may be that certain mediastinal abscesses of unknown origin have formed in this way. On the other hand, healing may take place with contraction which may compress or form diverticula in the neighboring structures, as the bronchi, pleuræ, pericardium, or œsophagus. Such contracted glands are usually deeply pigmented from accumulations of coal dust, and it is suggested that the presence of large quantities of this dust may in itself be sufficient to cause the growth of connective tissue with contraction.

Tuberculosis is undoubtedly responsible for the great majority of cases of enlargement of the bronchial glands. It may appear either in the acute miliary form, giving rise to no clinical symptoms, or in the caseating form. It was long supposed to be secondary to pulmonary tuberculosis, but the opinion has been steadily gaining ground that the glands in children are more apt to be the seat of primary infection than of secondary. Biedert, in 1884, collected 84 cases of primary bronchial-gland tuberculosis in children as against three secondary to pulmonary or vertebral tuberculosis. Not only this, but the bronchial glands may show tuberculosis in the absence of any other focus of infection. Steiner and Neuretter found tuberculous bronchial glands in 275 out of 302 children, and in 36 of these there were no other tuberculous organs. The bacilli in such cases enter by the respiratory tract and follow, according to Weigert, the route taken by the coal dust, lodging in the bronchial glands, as is evidenced by the frequency of tuberculosis in these glands compared to the mesenteric. Berthelot found the proportion to be as 20 to 1.

Tuberculous infection in these glands may remain latent for long periods of time and indeed may never give rise to demonstrable lesions. The inoculation experiments of Loomis showed that six out of fifteen persons dying of acute infectious diseases, and in whom no tuberculous lesions were found post mortem, had living tubercle bacilli in their bronchial lymphatic glands. Loomis' work is open to criticism as he used no control animals; but the same cannot be said of Pizzini, who used all possible precautions and yet succeeded in proving the presence of tubercle bacilli in the bronchial glands of forty-two per cent. of healthy non-tuberculous adults dying from accident, suicide, or acute infectious diseases. According to Weigert, this latency of the germs is to be explained by closure of the outgoing lymphatics; according to others, by the slight tendency to caseation in the bronchial glands which are already fibrous and pigmented.

An appreciable amount of enlargement may be found post mortem, although no symptoms were observed during life; but usually there are symptoms of contraction, or pressure or inflammation. The tuberculous glands may become adherent to the bronchi, œsophagus, pericardium, or large vessels, and may open and discharge into these, as in a case reported by Powell in which a scar was formed at the site of a perforation of the trachea; or they may cause compression, as in Pitt's case of enlarged and caseated posterior mediastinal glands which compressed the trachea and right bronchus. Parker, Gulliver, Goodhart all report cases of sudden death from dyspnœa caused by the rupture of a caseous gland into the trachea or into a bronchus; Malsin, Coupland, and Gee report death from dyspnœa caused by compression of trachea or bronchus. More rarely rupture is into the mediastinum. Secondary infection from these glands involves the lungs, the pleuræ, pericardium, and perhaps most commonly the meninges.

The symptoms of tuberculosis of the bronchial glands with enlargement and cheesy degeneration are: vague pain which is apt to be at the level of the fourth dorsal vertebra on one side or both with tenderness on pressure. Rarely the pain is substernal ("pain in the stomach"). Or there may be simply a feeling of pressure without actual pain. The cough is paroxysmal, like that of whooping-cough, but differs from it in its non-infectious

nature and its unlimited duration and obstinate recurrence. It is perhaps caused by irritation of the recurrent laryngeal nerve, but more probably by pressure on the trachea especially at its bifurcation, a point of very sensitive reflex. Dyspnœa may be so extreme as to suggest involvement of the vagus. Dysphagia is apt to be slight and is often considered hysterical, especially as nothing is revealed by examination with the sound. It may disappear after rupture or contraction of the glands.

Compression of the large vessels is shown by the frequent nose-bleeds, by the prominence of the vessels of the face, neck, and thorax, by clubbed fingers, and rarely by œdema. Sputum is often not present at all; when present it may be purely catarrhal or œdematous with streaks of blood. Michael saw a fatal hemorrhage which proved to have come from the rupture of a caseous gland into a blood-vessel and a bronchus simultaneously. The voice is apt to be weak or hoarse, and in extreme cases there is complete aphonia from pressure on the recurrent laryngeal nerves. Vomiting is probably due to pressure on the vagi.

Inspection reveals signs of venous stasis in the prominent veins of the thorax and neck, possibly even of the face; rarely a fulness or a diminished expansion of one side. Palpation reveals enlarged cervical glands, especially those which can be felt on deep pressure in the suprasternal notch, when the head is bent forward; also a certain rigidity of the trachea in inspiration and expiration or perhaps a one-sided displacement of the trachea. Vocal fremitus may be increased over certain areas of the chest. No changes may be detected on percussion, but in a minority of cases a diminished resonance may be detected between the shoulder blades extending from the second to the sixth dorsal vertebra, usually more marked on the right side as the glands on this side are larger and more numerous than on the left. Occasionally this diminished resonance is found over the same area anteriorly. Arnoux considers dulness under the right sterno-clavicular articulation an important sign. On auscultation over the interscapular space a rough blowing respiratory sound, with much prolonged expiration, may be detected. There may be a decided difference in the sounds on the two sides.

The diagnosis of bronchial-gland tuberculosis is not difficult in children, in whom such an affection is quite common, but its rarity among adults makes mistakes in diagnosis more frequent here. Symptoms of œsophageal narrowing in tuberculous adults with palpable cervical glands would make such a diagnosis probable; but one would be obliged to rule out mediastinal tumors, syphilis, and lung carcinoma or sarcoma.

The treatment, to be successful, must as a usual thing include a complete change of surroundings, and prolonged residence in the open air in a favorable climate. Probably the choice of a favorable climate resolves itself into one in which out-of-door life is possible, whether this is on the seashore or in the mountains. Bathing, gentle massage, inunctions with oleaginous media, as lanolin, or even cod-liver oil, cold compresses at night, and tepid sponging in the morning, are recommended as general treatment. Internally, cod-liver oil still holds its place as the remedy par excellence in such cases, although arsenic, the phosphates, hypophosphites, and glycerin have been recommended.

Tumors of the lymph glands lead us to the consideration of mediastinal tumors in general.

TUMORS.—The structures in the mediastinum which may be starting-places for new growths are the thymus gland, the thyroid gland with its occasional accessory thyroids, the lymph glands, and the connective tissue. Such tumors as originate in the viscera or serous membranes in this region are, strictly speaking, not included among mediastinal tumors, although in the later stages of their development they may come to lie in the mediastinum, and it may be impossible to determine their true origin.

Benign growths of the mediastinum are not common. Lipomata growing from the subpleural fat have been reported (Hare, Krönlein, Gussenbaum). Large fibromata, usually under the sternum and compressing the trachea, have been found in five instances (see Hare's article on "Affections of the Mediastinum," Phila., 1889.

The most interesting as well as the most numerous, to judge from the reported cases, are the dermoid cysts, the earliest report of which was made in 1827. Christian has collected forty cases since that date. These tumors are usually soft, fluctuating, sometimes pulsating, either from their own rich vascular supply, or, what is more probable, from transmitted aortic pulsations. They are apt to lie under the clavicle on one side or on both sides of the sternum, and are almost invariably diagnosed at first as aortic aneurism. The contents of the cysts are sebum, atheromatous débris, hair, squamous epithelium, sometimes teeth, fat, cartilage, and bone. Waldeyer describes one which was as large as a child's head, and pedunculated, its pedicle consisting of veins, arteries, and thyroid tissue. Marchand's cyst contained fat, and bodies resembling Hassall's corpuscles. Three of the forty cases of Christian showed evidences of malignancy. These tumors are usually benign in character, but from their situation necessarily dangerous, as rupture may take place into the pericardial sac, into the pleural cavity, into the left lung, into a bronchus, causing aspiration pneumonia, or into the aorta with fatal hemorrhage. On the other hand, dermoid cysts of the mediastinum are operable and their removal is a perfectly justifiable surgical procedure. The importance of diagnosis between these benign tumors on the one hand and malignant tumors or aneurism on the other becomes therefore very great.

The points to be emphasized in such a diagnosis are: the slow growth of the tumor and the absence of cachexia, which rule out malignant growths and metastases; the fact that characteristic symptoms of aneurism are either absent or when found are not proportioned to the duration of the disease, nor do they progressively increase, as would be expected in aneurism. In some cases (20 per cent. of all, according to Christian) the diagnosis has been made from the presence of hair in the sputum.

Simple cysts have been found in the mediastinum, and Marfan has collected four cases of echinococcus cysts.

Another form of benign tumor of the mediastinum has its origin in the thyroid gland proper or in an accessory thyroid. Wuhrmann finds in the literature ninety-one such tumors, seventy-five of them benign, sixteen malignant. The thyroid is occasionally situated much more deeply than usual, lying behind the sternum with its lobes between the trachea and the œsophagus, while accessory thyroids may be found anywhere within the space bounded above by the base of the tongue, below by the arch of the aorta, laterally by the large vessels of the neck, and posteriorly by the spinal column. It is therefore possible to find adenomata, carcinomata, or sarcomata of thyroid origin behind the clavicles, or behind the sternum, compressing the trachea or still deeper. Osler found an adenoma in the pleura. They may be quite isolated or connected with one or both lobes of the gland, or attached to it by a cord-like pedicle. Dittrich reported a substernal "endothoracic struma" the size of a man's head, which had compressed all of the right lung.

As in the case of dermoid cysts the diagnosis is at once difficult and extremely important, for the great majority of these thyroid tumors are benign and operable. Braun removed one from a woman fifty-eight years old. Those cases in which the tumor is palpable, and especially those in which a cord can be felt running to the region of the thyroid, or in which absence of one or both lobes of the gland can be made out, are not so difficult to recognize, but some of the deeper-seated ones are not palpable at all. Birch-Hirschfeld found such a one at an autopsy on a woman who was supposed to have suffered from a severe cardiac neurosis.

The most important and by far the most numerous tumors of the mediastinum are those which arise in the lymphatic glands. Of these some are described as be-

nign and are designated lymphoma or lymphadenoma; others are malignant and are variously named lymphosarcoma, malignant lymphoma, round-celled sarcoma, fibro-sarcoma, alveolar sarcoma. The confusion which exists in our text-books on the subject of lymphatic tumors, general and localized, cannot be cleared up at this time, for our knowledge of the relation of such tumors to diseases of the blood-building organs is as yet too vague, and it is impossible to draw a sharp line between the so-called hyperplasias with and without blood changes, and the neoplasms proper. Perhaps the simplest classification which can be made is that which places under one head the general hyperplasia of lymphatic glands, liver and spleen (leukæmic and pseudoleukæmic enlargement), and under the other the localized enlargements, or tumors, dividing them further into benign and malignant. Under the head of benign tumors of the lymph glands we have the lymphoma or lymphadenoma, a localized, benign enlargement of one or more lymphatic glands, distinguished on the one hand from lymphosarcoma by its non-malignancy, on the other from leukæmic and pseudoleukæmic lymphomata by its circumscribed character, and the absence of leukæmia or anæmia and of characteristic enlargement of spleen and liver.

The malignant lymphatic tumors have been variously designated as lymphosarcoma, malignant lymphoma, round-celled sarcoma, fibro-sarcoma, alveolar sarcoma. Ohlmacher is inclined to make no distinction between the different sarcomata which arise in lymphatic tissue. On the other hand, Kundrat thinks there is an essential difference between lympho-sarcoma and other forms of sarcoma. According to him lympho-sarcoma has a characteristic mode of increase and invasion. It is enormously infiltrating and insinuates itself into the spaces between organs and vessels, gradually fusing them into one mass but not causing rupture as do most malignant growths. It spreads not only by infiltrating the surrounding structures but by involving the other lymph glands, and instead of forming nodular metastases in the parenchymatous organs it forms its metastases by preference in the solitary follicles of the intestinal tract. Fibro-sarcoma may have the same situation as lympho-sarcoma, but is not so infiltrating, does not attain such an enormous size, and forms metastases in the usual places.

We may, therefore, consider that the primary tumors arising from the mediastinal lymph glands are lymphoma, lympho-sarcoma, and perhaps fibro-sarcoma, or round- or spindle-celled sarcoma, although these last might be regarded as arising, not in the lymph glands, but in the ordinary connective tissue. The same would be true of the rare cases of endothelioma and alveolar sarcoma. Primary carcinoma of the lymph glands, often spoken of in the older literature, is now regarded as a misnomer.

The lymphatic tumors of the mediastinum are usually soft, creamy tumors with thin-walled vessels, growing rather rapidly, but on the whole not so rapidly as do the majority of malignant tumors, or as do the lymphatic tumors of leukæmia; and sometimes they are of very slow growth. The cells break through the capsule of the gland and infiltrate the surrounding tissues, gradually fusing them into a large mass, from which crab-like prolongations resembling carcinoma can be seen extending still farther. Colossal tumors are formed, larger than those formed by any other variety of sarcoma, and involving all of the structures in the mediastinum. Kundrat reports a large tumor in a woman of sixty, which had so completely filled the left lung as to occlude the bronchus and reduce the lung to islands of collapsed pigmented tissue. Such a tumor has been known to involve the sternum and the vertebral column, reaching the meninges through the intervertebral foramina. Rupture of vessels is rare, compression with thrombosis is the more usual result (Kundrat). The tumor is rare in childhood, appears between the twenty-fifth and fifty-fifth years, is twice as frequent in men as in women, and seems to attack the strong and well-developed by preference. It is singular that very few show signs of previous tuberculosis of the lungs or of the remaining lymph glands. Metastases, as already stated, are found in the intestinal tract, more rarely in the liver, spleen, and kidney, where they tend to be very infiltrating, but are not accompanied by the general enlargement of the organs in question which occurs in leukæmia and pseudoleukæmia.

The histology of these tumors is very simple, and we cannot, on the grounds of microscopical structure, draw any line between the many varieties which have been distinguished macroscopically and clinically. They all consist of small round cells, held together by a varying amount of reticular connective tissue, and enclosed in a capsule which cannot be stripped off without tearing off some of the tissue. Giant cells and spindle cells are not often seen. Cysts may form, thus rendering the tumor very soft, or there may be enough fibrous reticulum to make it hard.

Secondary tumors of the mediastinum appear in the lymph glands almost exclusively, and may be either epithelial or sarcomatous; the former are secondary to carcinoma of the mammary gland, of the lungs, and very seldom of the gall bladder, kidney, or stomach. It is remarkable that the bronchial glands proper often escape in cancer of the œsophagus, and sometimes in carcinoma of the lung, although in other cases these may be the only glands involved, as in a case of Powell's in which a carcinoma of the head of the pancreas formed metastases in the bronchial glands alone. Secondary sarcoma is not so common, but it has been found following sarcoma of bones of the upper extremities.

The symptoms are those which are common to all malignant tumors and those which are caused by pressure upon the contents of the mediastinum. Subjective sensations are at the earliest stages limited to a feeling of pressure and fulness usually referred to the neck, and palpitation of the heart, but no pain. Intercostal neuralgia is not at all typical. The temperature varies; there may be irregular fever for many months, though it is difficult to understand what should cause it in an uncomplicated case. The position assumed by the patient is not characteristic, being now with the head thrown back, now with the head bent forward; again, it may be kneeling with the head on the crossed arms. As these positions are assumed to relieve the dyspnœa, they are assumed only in the later stages when the tumor has attained such dimensions as to cause pressure. This dyspnœa is variously explained as being caused by pressure on the trachea, bronchi, and recurrent laryngeal nerves, and on the veins of heart or lungs. It may be impossible to decide just which is involved in a given case, yet there are certain signs which aid in the diagnosis. Pressure on the veins would cause cyanosis, on the heart would alter the pulse rate and strength, and on the recurrent laryngeal nerves would cause laming and partial closure of the glottis. Characteristically the dyspnœa of mediastinal tumors is of long duration and unintermittent; but in some cases, as a result of raising of the blood pressure in a very vascular tumor, or from accumulation of the secretion in the narrowed trachea, it develops suddenly and is fatal. Irritation of the vagus is probably responsible for the cough, vomiting, palpitation, regurgitation of food, and girdle sensation observed in some cases; irritation of the sympathetic for the dilatation of the pupil on the affected side. In a case of Demmé's there was complete destruction of this nerve with contraction of the pupil. Irritation of the phrenic nerve (very rare) causes severe neuralgia and singultus, but strangely enough no dyspnœa. Pressure on the aorta causes a difference in the radial or carotid pulses of the two sides. Compression of the œsophagus is quite common.

Inspection.—Enlarged veins anteriorly or posteriorly; œdema of the neck and shoulder, or arm, or over the sternum; but this œdema is apt to appear early in the disease and then disappear even when the venous stasis persists. There is sometimes a fulness visible on the affected side; pulsation has been observed transmitted from heart or aorta or from the vascularity of the tumor itself, as in Letulle's right-sided tumor, which he describes

as resembling a "second heart on the right side." Sometimes the growth may be felt in the suprasternal notch.

Percussion.—Dulness according to size and position, usually behind in the interscapular space, or in front on both sides of the sternum, but always with characteristically irregular outlines. Letulle thinks there is sometimes a tympanitic resonance over posterior mediastinal tumors which push forward the lung. The heart dulness may be displaced.

Auscultation shows the same signs as in tuberculosis of the glands, and is valuable not only in revealing pressure on the bronchi and lungs, but also negatively in helping to make the diagnosis between mediastinal tumors and aneurism, although in some cases pressure on the aorta may give rise to a systolic sound very like the aneurismal bruit.

Other conditions which must be thought of in diagnosing these tumors are: syphilis with enlargement of the glands and ulceration and cicatrization of the trachea (Lazarus); malignant tumors of the lung and pleura, which, however, do not attain the enormous size of mediastinal tumors, cause metastases in the parenchymatous organs, and do not cause such marked symptoms of venous stasis; phthisis, in which case the sputum would be diagnostic; tuberculosis of the glands, which in adults is usually attended with tuberculosis in some other organs, and in children is common, while mediastinal tumor is rare; and, most important of all, benign tumors which are operable. In this last case the long continuance without marked increase of the symptoms is the chief aid to diagnosis, except when a connection with the thyroid gland can be made out.

The treatment of tumors in the mediastinum is possible only in the cases which are fit for operation; in all others we can only seek to relieve the symptoms. Leeches applied to the suprasternal notch or large sinapisms to the chest will sometimes relieve the dyspnœa. The physician is often driven to try tracheotomy to relieve this most distressing symptom, but this is useless, the compression being too far down, and the insertion of a cannula being apt to set up dangerous inflammation, even pressure gangrene. In the last stages pain may be so great as to defy opiates, but it may partially yield to the application of a large ice-bag to the chest or to the constant electric current with large flat electrodes. Hoffman got temporary relief in one very obstinate case by injecting carbolic acid into the tumor. All varieties of counterirritation have been tried, from wet and dry cupping to *Baunscheidtismus*, but without encouraging results.

Mediastinitis.—Inflammations of the mediastinum may be described as traumatic, extension, metastatic. The first class is caused by external wounds or injuries from foreign bodies in the œsophagus, instances of which are not infrequent, judging from Hare's statistics. Those which belong to the second class are the most common, and may be non-suppurative, suppurative, or tuberculous. The non-suppurative are secondary to pericarditis or pleuritis. Hare has collected sixteen such cases. Suppurative inflammation may extend from the neck along the large vessels, or from the larynx and trachea, or from the œsophagus; or from suppurating retropharyngeal glands in children, or from suppuration in the lungs or thymus or bronchial glands.

Tuberculous inflammation extends from the vertebræ or lymph glands, and is generally suppurative also. Metastatic mediastinitis has been found in typhoid fever and erysipelas, and in a few instances of acute articular rheumatism, pneumonia, and smallpox. It is much more common in men than in women; the proportion, according to Hare, being as fifty-eight to seven.

Mediastinal abscesses are apt to force their way through to the surface of the chest, but they have been known to break into the trachea, œsophagus, pleural cavity, pericardial sac, left ventricle, and aorta.

The symptoms are as follows: throbbing pain in the chest and back, increasing until the abscess is formed or until it evacuates; a feeling of heat and fulness; fever, chills, sweating, and rapid pulse. Symptoms of compression resemble those in tumors. Physical signs are usually absent until the abscess is fully enough developed to give symptoms of compression and suppuration. Œdema over the sternum is a valuable diagnostic point; the rapid course of the disease is also important.

Treatment consists in opening and draining the abscess, sometimes by resection of a part of the sternum. Heyfelder reviews twenty-five cases of resection with fifteen recoveries. Hemorrhage and emphysema of the mediastinum have been reported following wounds of the chest, œsophagus, or trachea. The latter is usually not fatal, even when the tissues of the neck and chest are filled with air. Knistern reports an interesting case in which the heart sounds were completely obliterated and a tympanitic resonance was heard over the heart dulness and over the upper part of the liver; but the air was rapidly absorbed and a complete recovery followed.

Very little is known of syphilis of the mediastinum. It appears to be usually regarded as an extension from gummata of the sternum or ribs. Weber had a case of gumma of the inner surface of the sternum with enlargement of the mediastinal glands. These large masses give rise to symptoms like those of tumors, and their true nature is revealed only at autopsy. *Alice Hamilton.*

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MEDICAL LAKE.—Spokane County, Washington.

Post-Office.—Medical Lake. Hotels.

Access.—Viâ Central Washington branch of the Northern Pacific Railroad to Cheney; thence eight miles northwest to lake.

This remarkable body of water is about a mile and a half in length by one-half mile in width. It is located on an elevated plateau, and is surrounded by an evergreen border of pine, fir, and tamarack. There are four good hotels on the lake, commodious bathhouses, splendid drives, delightful camping places, and an abundance of fish in the neighboring lakes. The East Washington Hospital for the Insane is also located here. The waters of the Medical Lake were analyzed by G. A. Mariner in 1832, with the following result:

One United States Gallon Contains:

Solids.	Grains.
Sodium carbonate	63.54
Lithium	Trace.
Magnesium carbonate	.23
Iron carbonate	.53
Calcium carbonate	.18
Sodium chloride	16.37
Potassium chloride	9.24
Aluminum oxide	.18
Sodium metasilicate	10.63
Potassium sulphate	Trace.
Sodium biborate	Trace.
Organic matter	.55
Total	101.45

The water has excellent properties as an antacid, laxative, and diuretic. It is used commercially. The evaporated salts resulting from distillation are also packed and shipped to different sections of the country. It is said that an excellent quality of soap is prepared from the residue. *James K. Crook.*

MEDICATING, MODES OF.—Medicines act only by coming into actual contact with the part *primarily* to be impressed, and the various *modes of medicating*, so called, are simply different methods for securing such contact, varying according to circumstances. Modes of medicating fall naturally into two categories, namely, first, modes of direct medication of surface parts immediately accessible to local application; and, secondly,

modes of medicating internal parts accessible only through the avenue of the blood. Medication by any of the methods of the first category is commonly spoken of as *local* medication; and by any of the modes of the second category as *general* medication. But concerning this phrase "general medication," the point must be noted that, although in one sense medicating by the avenue of the blood is always "general," for the reason that the medicine necessarily goes wherever the blood circulates, yet the *therapeutic application* is in many instances as purely local as if the drug had been locally applied from without. Thus, for instance, copaiba, swallowed, circulates generally with the blood, in which its virtues become dissolved, but yet the main influence of the drug and the entire therapeutic purpose thereof are commonly upon the surface of the urethral mucous membrane, with which the medicine comes into contact by excretion by the kidneys, dissolved in the urine.

I. Modes of Medicating by Direct Application.—In medicating the *skin*, the following points are to be noted: *First*, although the skin is comparatively insensitive and non-absorbent and so will bear stronger applications than will mucous membranes, yet there are many substances that will severely irritate even the sound skin, and many others that can be absorbed by the skin in sufficient quantity to produce constitutional effects; *secondly*, different parts of the skin differ greatly in sensitiveness, thin parts being more sensitive than thick, and, similarly, individual skins will vary in tenderness, thin and fine-textured skins being more sensitive than the coarse and thick. Also, of course, a *clean* skin is more readily affected than is a long-unwashed and dirty one. The *third* point is, that in the medication of hairy portions of skin, the effect will be far more thorough if the hair be shaved, or at least cut short, before the application is made. *Fourthly*, it is to be remembered that the skin, as a whole, constitutes an organ whose functions it will not do wholly to suppress. The persistent covering of the entire skin with matters impervious to the air is therefore fraught with mischief, and even danger.

Besides the skin, the *mucous membranes* present surfaces more or less accessible for direct medication. Here, far more than in the case of the skin, is to be found a great difference in sensitiveness in different parts. According to locality, therefore, applications intended for mucous membranes must vary widely in strength. The *least* sensitive mucous membranes are those of the *alimentary canal*, and of the *female generative organs;* the *middling* sensitive are those of the *conjunctiva*, the *air passages* beyond the larynx, the *middle ear*, the *lower* portion of the *nasal cavity*, and the *urethra;* while the *extremely* sensitive are the mucous surfaces, respectively, of the *cornea*, the *upper* portion of the *nasal cavity*, and the *larynx*. Another point is the very different degree of *accessibility* of mucous membranes. Some mucous membranes, as for instance that of the mouth, are as easily accessible as the skin itself, while others, such as that of the bladder, can be reached only by special instrumental appliances. The practical points concerned in medicating the different mucous membranes are as follows:

Medication of the Conjunctiva.—The conjunctiva is directly accessible, and medicaments can be applied in solution, in ointment, in powder, or, as in the case of nitrate of silver, by a touch of the solid substance. The only technical point in medicating the conjunctiva is thoroughly to expose the retrotarsal fold for the application, when, as happens in the majority of cases in conjunctival affections, the point of greatest intensity of the disease is situated exactly in that locality. To this end the patient should be directed to cast the eyes strongly downward, while the surgeon draws the everted upper lid upward and backward. Another caution well to note in this place is to avoid any application of a salt of *lead*, if there be any loss of the epithelium of the cornea, whether by an ulcer or an abrasion. This, because upon any exposed surface of corneal tissue proper, the application of a lead solution will determine an indelible, white opacity.

Medication of the Nasal Cavity.—The *lower* portion of the nasal cavity may be medicated by the snuffing up of dry powders or of solutions—a very imperfect measure in either case. More thorough is the blowing in of powders by a blast from a rubber bag, or the injection of solutions. But, as regards the latter procedure, the danger must be remembered of the injected fluid passing up the Eustachian tube to the middle ear, with, possibly, disastrous consequences. Direct injection from the anterior nares, and the so-called *nasal douche*, where the injected fluid enters one nostril and, passing around, escapes anteriorly by the other, are measures nowadays very justly condemned by the majority of practitioners. The safest means of flushing the nasal cavity with a solution is by the *posterior nasal syringe*, but even this measure is accused of occasionally producing middle-ear inflammation. *Atomized spray*, driven into the nose from before or behind, is, naturally, far safer than solutions in bulk. To medicate the *upper* portion of the nasal cavity, the same means are available as just described, with the same inherent dangers; the only point to note being that this same upper portion of the Schneiderian membrane is very much more sensitive on the one hand, and difficult of access on the other, than the lower. It is often doubtful whether insufflations or injections, whether of solutions in bulk or of spray, reach the upper regions of the nasal cavity at all. The mucous cavities, respectively, of the ethmoid and sphenoid bones, the frontal sinuses, and the antrum are practically inaccessible to direct medication.

Medication of the Eustachian Tube and Middle Ear.—In cases of perforation of the ear drum the middle ear is accessible to injections through the external auditory canal, but otherwise can be reached only by injections or insufflations through the *Eustachian catheter*, a specially shaped catheter introduced through the nostril so as just to engage the opening of the Eustachian tube. Concerning medication through the Eustachian catheter, the only points proper to note in this article are that, in the first place, the manipulation of the catheter itself requires technical knowledge and skill, and in the second that the mucous surfaces under consideration are very sensitive to irritation, so that mischief instead of benefit may easily result from over-zealous practice of direct medication.

Medication of the Mouth and Pharynx.—The *mouth* may be medicated by mouth-washes, by troches, or by direct localized application at the hands of the surgeon in any of the ordinary ways. The *pharynx* is medicated by applications of spray, by injections by means of the posterior nasal syringe, or by solutions exactly applied by a mop attached to a properly shaped handle introduced through the mouth. Strong applications are best made by the latter method, since sprays and injections may, undesirably, find their way into the larynx or into the posterior nares. *Gargling* is fairly efficacious for medicating parts anterior to the faucial arch, but is of little avail for affecting the pharyngeal region.

Medication of the Larynx.—The larynx is medicated by the inhalation of vapors or of solutions in spray, or, at the hands of the surgeon, by local touch by means of special probangs applied with the help of a view in the laryngoscope. Technical training and a delicate hand are necessary in laryngeal manipulation, and the extreme sensitiveness of the mucous membrane of the larynx to irritant applications must ever be borne in mind.

Medication of the Respiratory Mucous Membrane beyond the Larynx.—The air passages beyond the larynx can be medicated directly only by *inhalation*. Vapors and solutions in spray can be inhaled with a view to medicinal effect, but the *vapors* must be such as are non-irritant, and as regards *sprays*, the whole drift of exact observation tends to strengthen the belief that fluids inhaled in spray never penetrate beyond the larger bronchial tubes.

Medication of the Bladder and Urethra.—The *urethra* is accessible by injections, by medicated "bougies" of cacao butter, and by the sound, smeared with the medicament in ointment or in any pasty condition. The *bladder*

is reached only by injection through the catheter. The mucous membranes of these localities belong to the sensitive class, and the introduction of fluids or instruments not *germ-sterilized* into urethra or bladder may determine cystitis. What is practically a local medication of the urinary mucous membrane is afforded by the action of such medicines as buchu, cubeb, and copaiba, when taken by swallowing. The active principle of such drugs is excreted, possibly more or less changed, by the kidney, and so, being dissolved in the urine, makes a local impression upon the mucous membrane of the urinary tract.

Medication of the Female Genital Mucous Membrane.—The *vagina* can be reached by medicated suppositories, by injection, or, its surface being exposed by a speculum, by brush or probang at the hands of the surgeon. As a considerable volume of fluid is required for a thorough vaginal injection, the "fountain" syringe is here peculiarly convenient. A fountain syringe is simply a good-sized rubber bag with a long tube leading from its lowest point. The bag is filled with the injection fluid and hung upon the wall at a height of three feet or more from the level of the part to receive the injection, whereupon gravity determines a steady and strong flow. The force of the stream is regulated by the height at which the bag is hung. The rubber tube is fitted with the necessary nozzle and also with a simple form of clamp to shut off the flow. The *uterus* is accessible to special instrumental appliances, including means for making injections; but, as regards the injecting of this organ, it must never be forgotten that there is an open communication through the Fallopian tubes between the cavity of the uterus and the general peritoneal sac. Peritonitis and death have more than once resulted from a uterine injection.

Medication of the Mucous Membrane of the Alimentary Canal.—The mucous membrane of the *stomach* is, of course, easiest reached by administration of a drug by swallowing; otherwise by use of the stomach pump. A stomach pump is a good-sized syringe with a double nozzle end fitted with a two-way stopcock appliance. From the nozzle end two tubes make off at right angles, whereof one goes into the stomach and the other into a basin. By proper manipulation of the two-way cock, fluid may be drawn up from the basin and thereupon discharged into the stomach, or *vice versa.* The mucous surface of the *small intestine* is practically accessible to direct medication only by administration of the drug by swallowing; but that of the *large* intestine, and most especially of the *rectum,* can be reached also by anal injection, or in the case of the rectum, also by suppository. A rectal injection intended for local medication should be small in bulk—not over two fluidounces; should be blood-warm, and should be *slowly* administered. The rectum should first be washed out by injections of plain water. In practising a rectal injection, the points should be observed to have the nozzle of the syringe *warm* and *well greased,* and to direct the same, after the sphincter has been passed, *upward* and *backward,* to conform to the lay of the rectum in the concavity of the sacrum. In the case of children crying during the operation, the further point should be observed to force entrance during *inspiration* only, when the abdominal tension is relaxed, merely holding ground, without attempting to advance, during the strained *expiration.* On withdrawing the nozzle after the injection has been finished, a little firm pressure with the fingers or a towel end should be made upon the anus until all reflex quivering of the sphincter shall have subsided.

In the medication of mucous membranes the use of solutions in condition of *spray* has several times been mentioned. A fine spray, for medicinal purposes, is gotten by the well-known so-called *atomizers.* An atomizer is, in essence, a very simple contrivance. A tube leading up from a vessel of fluid ends in a capillary orifice. Close to this orifice, and at right angles in direction, is set a similar capillary orifice of a second tube leading from some arrangement for delivering a blast—as of air from a rubber bulb squeezed by hand, or of steam from a small boiler set over an alcohol lamp. Such blast, then, by its close forcible passage immediately across the fine orifice of the first tube, sucks out the air from such tube, and, of course, also the fluid, which at once rises up the tube from the reservoir in which the tube is set, following the exhaustion of the air. But now, no sooner does a drop of fluid present itself at the capillary orifice of the tube through which it is drawn than, by the same blast that has sucked it up, such drop is immediately and literally blown to atoms—dispersed, that is, in exquisitely fine spray. In different atomizers different arrangements of the two related orifices obtain, but the finest spray is always to be found where the device is the original and simple one of having two very fine orifices accurately and closely set at right angles to each other. The *driving blast* is ordinarily obtained by hand pressure on a rubber air sphere connected with the atomizer proper by a rubber tube. Such "hand atomizers" also commonly have a second air sphere let into the rubber connecting tube between the terminal bulb and the atomizing apparatus. This second chamber, by its elastic distention, keeps up an air pressure during the intermittence of the play of the bulb directly compressed, and so a perfectly steady blast can be secured indefinitely. Should a momentary blast only be wanted, the same can be obtained by direct compression of the middle reservoir bulb instead of the terminal one. *Steam* atomizers, where the driving blast is steam from a small boiler, are particularly applicable for inhalations of spray, or for the delivery of spray of an "antiseptic" solution during surgical operations—in short, for all such occasions as require a prolonged atomization too tiresome to be maintained by use of the hand apparatus.

II. Modes of Medicating through the Avenue of the Blood.—As already stated, the only way to medicate parts out of direct reach is to put the medicine into the general vascular circulation. Nothing is easier, but now the point obtains that *localization* of the medication is impossible. The medicine will necessarily be diffused throughout the whole volume of the blood, and so will go to all parts alike where blood circulates. Accordingly, in general medication, the point always has to be considered whether the expected benefit to the organ or function to be treated may not perhaps be more than counterbalanced by derangement produced elsewhere. In view of this point the standard rule obtains always to select that medicine which will accomplish a maximum of the effect sought with a minimum of by-derangement.

For the introduction of a medicine into the circulation there are several means, as follows: The easiest and altogether most natural one is, of course, to give the medicine *by swallowing,* whereupon absorption of the medicine into the blood occurs by the same avenues as in the case of the products of digestion. And an inherent advantage of this method is that, to a considerable extent the stomach will assume the functions of a pharmaceutical laboratory, and extract the active ingredients of drugs administered in more or less crude condition. But despite these various advantages, there may arise circumstances making it unadvisable, or dangerous, or futile, to give medicine by the stomach. Thus, *First,* a medicine given by swallowing may greatly derange the function of the stomach itself—destroying appetite, upsetting digestion, or even provoking nausea and vomiting—when the same dose, given by the rectum or injected subcutaneously, might be borne without any substantial derangement; *secondly,* the giving of anything by swallowing may be debarred by the fact of a corrosive poisoning of the stomach, or of a stricture of the œsophagus; and *thirdly,* such administration might be useless, or worse than useless, because of *absorption* being in abeyance through *narcotic* poisoning, or through general collapse from any cause; *fourthly,* the very chemical activity of the gastric juices, so serviceable to extract certain active principles from crude preparations, may yet affect certain others injuriously; *fifthly,* the pres-

ence of food in the stomach may, in certain cases, seriously delay or impede absorption of the medicine.

Besides the stomach the *rectum* is more or less available as an avenue of approach to the circulation. The rectum, however, has not the chemical power of the stomach to extract, in soluble form, active principles from crude drugs. Hence, in aiming to medicate the system by the rectum, it is always advisable to use a form of medicine wherein the active principle is either already in aqueous solution, or is at least in such state as to be capable of dissolving directly in the fluids naturally to be found in the rectal cavity. Another special point is to give by the rectum about twice the dose of any given medicine that would be administered by the mouth.

Still another natural avenue of approach to the circulation is afforded by the *lungs*. Absorption by the lungs is speedy and thorough; but obviously the use of this avenue is limited, since only medicines that are at once *volatile* and *not unduly irritant* can be introduced to the circulation through the lungs.

Next, it is possible to introduce medicines to the blood through the avenue of the *skin*, and that, too, in a variety of ways. Of these ways the simplest is merely to lay upon the skin cloths wetted with a fluid medicine, trusting to direct absorption of the medicated solution through the tissue of the skin. With some medicines, under such circumstances, absorption unquestionably occurs; but at best the method is so crude, and the results are so uncertain, that the procedure is not to be commended. The next method is by so-called *inunction*—the rubbing into the skin of the medicine in condition of ointment or oily solution. By this means, with certain drugs, certain, thorough, and rapid absorption is effected, so that inunction is an established and valued method of accomplishing constitutional medication. The only drawbacks to the method are the tediousness of the application, and the occasional soreness of the skin that may result from a repetition of inunction upon an identical skin area. A third method is *fumigation*, wherein a volatilizable medicine is sublimed in presence of aqueous vapor, and made to condense upon the skin. Under the conditions of such procedure, absorption is as rapid and thorough as in the case of inunction, and fumigation is, indeed, an alternate method to inunction. Obviously, however, but a limited number of drugs are capable of application by fumigation, and, practically, the method is confined to the administration of *mercury*. (For details of the method see Mercurous Chloride, under *Mercury*.) A fourth method is by the procedure of raising a small blister, and then, exposing the raw surface under the bleb, applying to the same the medicine in concentrated condition. This method, called the *endermatic*, is rapid and certain, but is painful and barbarous, and has practically been supplanted by the fifth and last method, that, namely, of injecting the medicine, in solution, by a small syringe, into the subcutaneous connective tissue—the well-known and popular *hypodermatic* method. By the hypodermatic method absorption is pre-eminently rapid, thorough, and certain—all impediments of varying gastric conditions on the one hand, or of nervous ones on the other, being void—and also, often, the medicinal impression is more radical than when the same drug is given in other ways. There are two drawbacks to the method, *first*, that it can only be used in the case of medicines that are, at once, *fairly non-irritant, soluble in bland menstrua*, and *effective in small dose;* and, secondly, that the injection requires the technical skill of the physician himself, or of a trained nurse. (For details of the hypodermatic method, see *Hypodermatic Medication*.)

Lastly, medicines can be introduced into the circulation by direct *intravenous injection*. In the case of *active* medicines this procedure is so dangerous as to be unjustifiable, but for the *passive* purpose of increasing the volume of the circulating fluid in order to arouse the heart in collapse, it is safe and serviceable. Milk, defibrinated blood, desiccated blood redissolved, and "indifferent" saline solutions, are the substances commonly injected. (For details of the method see *Transfusion*.)

Edward Curtis.

MEDICINES, FORMS OF.—Under this title will be discussed the class characteristics of the various kinds of medicinal preparations, so far as they immediately concern the physician. For convenience of reference, the different forms of medicines will be taken up in alphabetical order, and it will be understood that, in matters of pharmacopœial authority, the standard followed is that of the United States Pharmacopœia, Seventh Revision (Revision of 1890).

Abstract (Latin *Abstractum*, unofficial). By this term there was formerly designated a preparation, in dry powder, of a vegetable drug, of twice the medicinal strength, weight for weight, of the crude drug. An extract was first made, which was then brought to standard strength by the addition of sugar of milk. The class of abstracts was dismissed in the 1890 revision of the United States Pharmacopœia.

Bolus (Latin, *Bolus;* unofficial).—By a *bolus* is understood to mean a mass of a medicinal substance larger than a pill, which is yet to be swallowed whole after the manner of pills. Such form of administration of a medicine is so obviously objectionable that nowadays the "bolus" is rarely used.

Bougie (Latin, *Bougia;* unofficial).—A *bougie* is an elongated plug of cacao butter for insertion into the urethra or the uterus. The necessary medicament is incorporated into the substance of the bougie which melts in the natural warmth of the part.

Cerate (Latin, *Ceratum*).—A *cerate* is a preparation whose basis is an admixture of a fatty and a waxy body or bodies, so proportioned that the product shall be of fairly firm consistence, and of a melting point above that of the temperature of the skin. A cerate thus maintains the consistency of a soft solid when applied to the skin, and is intended to serve as a permanent dressing, being used spread upon a backing of muslin or kid. The preparation of the United States Pharmacopœia whose official title is the simple word *Ceratum, Cerate*, is a non-medicated simple mixture of white wax and lard, in the proportion of thirty parts of the former to seventy parts of the latter. Including this preparation, six cerates are official in the United States Pharmacopœia.

Confection (Latin, *Confectio*).—A confection is a material of the quality and composition of soft confectionery, intended as a pleasant menstruum for active medicines. Two confections only are official in the United States Pharmacopœia—one, a *confection of rose*, simply rose-flavored confectionery, suitable for extemporaneous medication, and the other a *confection of senna*, a confection feebly medicated with the drug senna. Confections are, of course, intended to be eaten, and are therefore appropriate for such medicines only as do not taste unduly bad. Confections are objectionable, generally, because of the large amount of saccharine matter that they contain.

Decoction (Latin, *Decoctum*).—When a crude vegetable drug is actually boiled in water for a greater or less time, the resulting aqueous solution of such principles as the boiling water will have extracted is termed a *decoction*. The process of decoction is suitable to such drugs only as do not have their active principle or principles either decomposed or dissipated by the heat of boiling; but even in the case of decoctions of appropriate drugs, the preparation will spoil by keeping, unless, indeed, the original drug contain some antiseptic substance. Medicinally, decoctions are objectionable because bulky, ill-tasting, and necessarily containing other constituents of the original drug substance than the active principle. The United States Pharmacopœia ordains two specific decoctions, namely, *decoction of cetraria* and *compound decoction of sarsaparilla*, and also a general formula for the making of decoctions of any drugs extemporaneously prescribed. Such general formula is as follows: "An ordinary decoction, the strength of which is not directed

by the physician, nor specified by the Pharmacopœia, shall be prepared by the following formula: take of the substance, coarsely comminuted, 50 gm.; water a sufficient quantity to make 1,000 c.c. Put the substance into a suitable vessel provided with a cover, pour upon it 1,000 c.c. of cold water, cover it well, and boil for fifteen minutes. Then let it cool to about 40° C. (104° F.), express, strain the expressed liquid, and pass enough cold water through the strainer to make the product measure 1,000 c.c. *Caution.*—The strength of decoctions of energetic or powerful substances should be specially prescribed by the physician" (U. S. P.). The average dose of a decoction prepared by the above formula is from one to two fluidounces.

Disc (Latin, *Discus;* unofficial).—A *disc,* as a form of medicine, means a small gelatin scale of microscopical thickness, impregnated with some medicinal substance, generally a salt of an alkaloid. Such medicated discs are especially devised as a convenient means of applying accurately apportioned, minute quantities of mydriatic or myotic alkaloidal salts to the conjunctiva. When so used the disc is lifted by the touch of a moistened, fine camel's-hair pencil, and gently laid on the inner surface of the lower lid, whereupon the gelatin of the disc is speedily liquefied by the warmth and moisture of the mucous membrane, so setting free the contained charge of medicament.

Elixir (Latin, *Elixir*).—The *elixir* of modern pharmacy is a preparation consisting of diluted alcohol, sweetened and aromatized, and containing, in weak charge, in solution, some medicinal substance or substances. The United States Pharmacopœia makes official a so-called aromatic *elixir,* intended as a simple, pleasantly flavored elixir basis, to be medicated by the prescriber at pleasure. This official elixir, like the majority of proprietary elixirs, is no less than twenty-five per cent. strength of alcohol—a fact seriously to be borne in mind in relation to the tablespoonful doses in which elixirs are commonly designated to be prescribed.

Emulsion (Latin, *Emulsum*).—An *emulsion* is a fluid mixture consisting of a fatty body diffused in a state of fine mechanical subdivision through a more or less viscid watery menstruum. Milk is a natural example of an emulsion. Emulsions constitute a serviceable form in which to administer fixed oils whose dose is considerable—such as castor oil and cod-liver oil—for the double reason that, in such condition, the oil is less apt to nauseate, and also permits of having its taste quite perfectly disguised. The agents most commonly used to emulsify fixed oils are gum arabic and yolk of egg. Of these emulsifiers gum arabic is the more generally serviceable; emulsions made with egg yolk being not so ready to form, and also, after making, being more prone to spoil. Gum tragacanth also may be used, but gives inferior results; and alkaline solutions, often quoted as emulsifiers, work with oils a chemical change—saponification—instead of the purely mechanical subdivision properly understood as emulsification. To emulsify with gum arabic, a thick mucilage is first made with a quantity of the gum equal to one-half the weight of the quantity of oil to be emulsified, and to this mucilage the oil is gradually added with thorough trituration, one portion of oil not being added until the previous one has been fully emulsified. After emulsification the product may be diluted with an aqueous menstruum, in quantity up to from eight to ten times the volume of oil represented in the emulsion. When yolk of egg is to be used, it should be taken in the proportion of one yolk to each fluidounce of oil. *Volatile* oils in considerable quantity are best emulsified by first mixing with two or three volumes of a bland fixed oil, and then emulsifying the mixture as in the case of a simple fixed oil. Mixtures of *resins* and of *balsams* in fine mechanical subdivision in viscid menstrua are also sometimes called emulsions. Such emulsions may be procured by the use of the same emulsifiers and method as above described. *Gum resins* may be emulsified by trituration with water alone, the gum of the gum resin serving to make the necessary mucilage for emulsification. Four emulsions are official in the United States Pharmacopœia.

Extract (Latin, *Extractum*).—The word *extract,* unqualified, expresses a preparation of solid or semi-solid consistence, made from a crude vegetable drug by one or other of the following processes. In by far the majority of instances—indeed, in the United States Pharmacopœia, in all instances but one of official extracts—the crude drug is acted upon by a solvent, generally alcohol or alcohol diluted, and the resulting solution is evaporated down to the proper consistence. In the other case, exemplified in the United States Pharmacopœia by the single instance of extract of taraxacum, the drug in the fresh state, bruised in a mortar with the addition of a little water, until reduced to a pulp, is subjected to expression, and the expressed juice, strained, is then evaporated to a pilular consistence. Extracts are of varying consistence, some being sufficiently hard to admit of pulverization, while others—and, indeed, the majority—are semi-solid in consistence, and of just the right degree of stickiness to permit of ready rolling into pills. Extracts are, for this latter reason, very commonly prescribed in pill form, and extracts of indifferent drugs, such as gentian, are much use as pilular excipients for dry powders. Extracts, especially those—such as extract of taraxacum—which are made by expression of the fresh drug, are apt to be uncertain in strength.

Fluid Extract (Latin, *Extractum Fluidum*). — The fluid extracts of the United States Pharmacopœia are preparations made by first extracting a vegetable drug with alcohol or diluted alcohol, then concentrating the resulting alcoholic solution by evaporation, and, unless the product be self-preserving, finally fortifying the same against decomposition by the addition of some appropriate preservative, generally glycerin. A further feature of the United States fluid extracts is the unique one of a fixed equivalent proportion between volume of product and weight of crude drug taken for the extracting, the equivalence being that between the units of volume and of weight of the metric system—so that, in short, each *cubic centimetre of fluid extract* represents the virtues of *one gram of crude drug.* Fluid extracts constitute a valuable class of medicinal forms, by reason of their concentration and keeping powers.

Glycerite (Latin, *Glyceritum*).—In the United States Pharmacopœia the title *glycerite* is given to a fluid preparation of which glycerin is the basis. Six glycerites are official.

Honey (Latin, *Mel*).—There is but a single medicated "honey" in the United States Pharmacopœia, namely, *honey of rose,* a preparation consisting of clarified honey mixed with a little of the fluid extract of rose.

Infusion (Latin, *Infusum*).—An *infusion* is a fluid preparation made by steeping a crude vegetable drug in water, cold or hot, and straining the product. Infusions, or "teas," as they are often called, are bulky, are generally ill-tasting, and also prone to decomposition. Except in the case of a few special infusions, viz., the infusions, respectively, of *cinchona, digitalis, wild cherry,* and *compound infusion of senna,* the United States Pharmacopœia contents itself with giving a general formula for the making of infusions, leaving the prescriber thus at liberty to order an infusion of any appropriate drug he may please. In such general formula the quantity of 50 gm. of crude drug, in coarse powder, is directed to be treated with 1,000 c.c. of boiling water, and the mixture to be set aside in a covered vessel for half an hour. The infusion is then to be strained, and enough water to be passed through the strainer to make the product finally measure 1,000 c.c. The Pharmacopœia enjoins the caution concerning infusions that "the strength of infusions of energetic or powerful substances should be specially prescribed by the physician." Of infusions generally, the average dose is from one to two fluidounces, but in the case of infusions of powerful drugs, as, for instance, infusion of digitalis, the dose may be very much less.

Juice (Latin, *Succus;* unofficial).—In pharmaceutical

nomenclature the term *juice* signifies a preparation consisting of the expressed juice of a fresh vegetable drug, to which enough alcohol has been added to preserve from decomposition. Two such "juices" were made official in the United States Pharmacopœia of 1870, but were dismissed in the revision for 1880. "Juices" are faulty preparations by reason of uncertainty of strength.

LINIMENT (Latin, *Linimentum*).—A *liniment* is a fluid or semifluid preparation intended for rubbing upon the skin. The liniments of the United States Pharmacopœia are so incongruous as to present no class features for general discussion.

MASS (Latin, *Massa*).—A *mass* in pharmacy signifies a *pill mass*, and is applied, in the nomenclature of the United States Pharmacopœia, to the instances of pill masses where no subdivision into pills of definite weight is ordained. Such instances are three in number (mass of *copaiba*, mass of *carbonate of iron*, and mass of *mercury*).

MIXTURE (Latin, *Mistura*).—In the United States Pharmacopœia the title *mixture* applies to many incongruous mixtures affording *fluid* preparations. The word is properly restricted to such preparations as represent an insoluble substance in powder mechanically suspended in a viscid fluid menstruum. Such condition of suspension is often a convenient one for extemporaneous prescription of powders. In so prescribing, the necessary viscidity is to be obtained by the use of a mucilage, or of syrup, or glycerin, ordered in the proportion of from one part to one, to one part to three, of watery basis. In such viscid menstrua five per cent. of powdered extracts, or twenty per cent. of light vegetable powders, may be ordered to be suspended. Heavy metallic powders, as a rule, should not be prescribed in mechanical suspension.

MUCILAGE (Latin, *Mucilago*).—A *mucilage* is the well-known viscid product that results from treating a gum with water, hot or cold, as the case may be. Some mucilages are perfect, and others but partial, solutions. Four mucilages are official in the United States Pharmacopœia. They are all simply bland viscid preparations, devoid of medicinal activity.

OINTMENT (Latin, *Unguentum*).—An *ointment* is a preparation of fatty quality whose melting-point is so low that the substance liquefies, partially or wholly, at the temperature of the body. Ointments are intended for application to the skin, either for purposes of local dressing or to medicate constitutionally by the method of inunction. The common bases for ointments are *lard*, either plain or benzoinated; *lard* with a small admixture of *wax*, or the well-known substance *vaseline* ("petrolatum" of the United States Pharmacopœia). Under the simple title *Unguentum*, Ointment, the United States Pharmacopœia makes official a mixture of lard, four parts, and wax, one part. Such "ointment" is convenient, both as a simple ointment itself, or as a simple basis for extemporaneously medicated ointments. A number of medicated ointments are official in the United States Pharmacopœia, of which the basis, in the majority of instances, is benzoinated lard. For this, however, the prescriber may, at pleasure, direct vaseline to be substituted.

OLEATE (Latin, *Oleatum*).—In the United States Pharmacopœia the title *Oleatum*, "Oleate," is applied to three preparations, the "oleates," respectively, of mercury, zinc, and the alkaloid veratrine. These preparations consist of the oleates of the respective bases, dissolved in an excess of oleic acid. Besides these preparations, however, the oleates of many other bases, metallic and alkaloidal, are offered by pharmaceutical manufacturers, and are considerably used in medicine. Of these unofficial preparations some, like the official so-called "oleates," are solutions of oleates in excess of oleic acid; while others, such as the forms of oleate of zinc and of lead in common use, consist simply of the chemically pure *oleates* themselves. Preparations consisting of oleates in solution in excess of oleic acid, are oily fluids or soft unguents; while some pure metallic oleates, such as those of zinc and of lead, are dry pulverulent bodies of a smooth, soapy feel. Oleates owe their medicinal use to the fact that they permeate animal tissue with unusual facility, after the manner of oleic acid, and so are at once elegant and efficacious for skin medication. It is also commonly held that, upon inunction, oleates readily pass through the skin, enter the general circulation, and so affect the system at large, both promptly and thoroughly. Some doubt, however, is thrown upon this alleged faculty, by the failure of some clinicians to obtain mercurialization by inunction with oleate of mercury—and that, too, in the case of individuals who, upon trial, were found to be affected readily by ordinary mercurial ointment.[1]

OLEORESIN (Latin, *Oleoresina*).—The *oleoresins* of the United States Pharmacopœia are preparations made by extracting with ether certain drugs whose medicinal activities reside jointly in oily and resinous constituents. After extraction the ether is evaporated and the oleoresin thereupon obtained in concentrated condition. The pharmacopœial oleoresins are thick fluids of concentrated medicinal strength. They are administered in capsule or emulsion.

PAPER (Latin, *Charta*).—Two medicated *papers* are official in the United States Pharmacopœia, viz., a paper of *mustard*, for local application, and a paper of *potassium nitrate*, for burning in order to get nitre fumes for inhalation.

PILLS (Latin, *Pilulæ*).—The *pill* is a favorite form for the administration of medicines, since in such form are combined the advantages of permanence, portability, exactitude of dosage, convenience of administration, and concealment of bad taste. The only drawbacks of the pill are comparative slowness of action as compared with powders or solutions, and the fact that many persons—all little children, namely, and also some adults—cannot swallow pills. The pill form is appropriate for any solid medicine which is not corrosive or deliquescent, and whose dose is within the weight of a few grains; and may even be employed in the case of certain fluids of small dosage such as croton oil. In order to be within bounds in the matter of size, pills, if composed of light substances, such as vegetable powders, should never exceed, individually, the weight of 30 cgm. (gr. v.), nor, if made up of heavy matters, such as metallic powders, the individual weight of from 40 to 45 cgm. (from gr. vi.–vij.). And pills are of most convenient size which do not weigh more than half such stated quantities. The proper *excipients* for pills will vary according to the nature of the basis ingredient of the pill. *Sticky vegetable extracts* need no excipient; such substances, indeed, constitute themselves excellent excipients for heavy powders. *Soft gum resins* also require no excipient, although in making such material into pills the addition of a few drops of alcohol may be necessary to reduce hardness. *Substances, fluid or semifluid*, acquire the proper consistency by admixture with some indifferent dry powder, such as pulverized starch or gum arabic. *Powders*, if heavy, are best treated by incorporation in some indifferent sticky vegetable extract, or in confection of rose; or, if light, by admixture of some viscid fluid, such as glycerin, syrup, or honey. Mucilage is unsuitable for such purpose because of its tendency to make the pill mass unduly hard when dry. For *resinous and fatty* bodies, *soap* makes a convenient excipient. In the prescription of extemporaneous pills it is commonly not necessary for the physician to specify the excipient—the selection of the appropriate substance being regarded as the function of the pharmacist. After being made, pills are variously *coated*. Shaking with an indifferent dry powder, such as lycopodium or liquorice powder, is the simplest procedure in such line, and suffices to prevent the pills from cohering, but does not conceal taste. For the latter purpose, if the pills have been freshly made, a convenient operation is the shaking of the pills in a box with silver or gold foil. By this manipulation the pills become covered with bits of foil which adhere fast enough to conceal taste during the act of swallowing, but which break away readily thereafter and so do not interfere with the solution of the pill in the stomach. By special processes, also, pills made by the wholesale are given

coatings of gelatin, sugar, or other analogous material. Such coatings necessarily delay the solution of the pill substance by the time required for their own solution. A special make of pill is what is called the *compressed* pill, wherein a light vegetable powder is made into pill form by mechanical pressure, without the use of any excipient. Such pills may be so hard as to be soluble with difficulty. The writer has known quinine pills of this make to be vomited, almost intact, several hours after swallowing. For the *administration* of pills, it suffices, with the majority of persons old enough to take pills at all, to put the pill, naked, upon the back of the tongue, and thereupon take a gulp of water. If, however, there be difficulty in swallowing under such conditions, the pill may be put in the middle of a pulpy mass, such as preserve or apple scrapings, and so offered for deglutition. Or, a method which the writer has found to succeed when all others fail, is to take a grape whose pulp will slip readily out of the skin, dig out the seeds, put the pill in their place, and then give the grape to be swallowed in the manner common to most persons—namely, to be taken by popping the pulp from the skin into the mouth, and bolting without chewing.

Quite a number of pills of special composition are official in the United States Pharmacopœia. In the majority of instances of these preparations, the Pharmacopœia establishes the weight for the individual pills as well as the constitution of the mass. Such official pills are then entitled *Pilulæ*, Pills. In three instances, however, the composition of the pill mass is alone directed, in which case the preparation is entitled *Massa*, Mass (see *Mass*, above).

Plaster (Latin, *Emplastrum*).—In pharmacopœial parlance the word *plaster* signifies a kind of stuff, intended for spreading upon a backing for the making of *a plaster*, in the ordinary sense of the phrase. Materials fit for plasters are such as are hard at ordinary temperatures, but soften readily and become sticky upon gentle warming. *Lead plaster*, so-called—an indifferent substance of just this quality—is the most common excipient for plasters. By their very nature, plasters can exert only the feeblest possible medicinal influence, and really act by gentle counter-irritation with exclusion of air and with mechanical support. For service, plasters are spread upon a backing of sheepskin or of cloth, and, according to quality, may or may not require artificial softening by a gentle heat before application. The majority of plasters are not affected by water, and hence, for removal, require stripping off by force. A corner should first be loosened, by action of a few drops of oil of turpentine, if hard to start, and then the plaster quickly stripped by a backward pull parallel to the trend of the part. Hairy areas of skin should be shaved before a plaster is applied, by which procedure the pain of stripping in greatly lessened. Plasters are prescribed by dimension in inches, not by weight, and are dispensed, ready spread, for use.

Poultice (Latin, *Cataplasma;* unofficial).—A *poultice* is a mass of soft, water-moist material intended for local application. In the great majority of instances such material is designed to be perfectly bland, the purpose being simply to maintain an application of warmth and moisture. The notable exception to such kind of poultice is the *mustard* poultice. The commonest poultices are as follows: 1. Flannels, or picked lint, wrung out in very hot water, and applied under some water-proof covering. Such material is cleanly, convenient, and light, but not over-smooth, and of little power to retain heat. 2. *Flaxseed meal* and hot water. This poultice keeps its heat well, but is heavy and irritating. 3. *Stale bread mixed to a pulp with hot water or milk.* The bread poultice is light and soft, but rapidly loses heat and easily turns sour. 4. *Yeast, flour, and water, set to "rise" and applied during fermentation*, a convenient and smooth material. 5. *Powdered slippery elm and hot water.* This material makes a particularly light, smooth, and unctuous poultice, well adapted for application to very tender parts. Poultices of flaxseed or slippery elm should be mixed by stirring the dry material, in powder, into a bowl of *boiling-hot* water, until a mass of proper consistence is obtained, instead of pouring the *water* upon a bowlful of the powder, as is sometimes improperly done. Poultices should always be abundantly *thick* and *big;* should be *hot*, and should be renewed often enough to maintain a continuous hot impression. If the necessary thickness make the mass too heavy, the poultice may be made comparatively thin, and then be covered with a thick layer of cotton batting. To maintain a prolonged heat effect, the poultice mass should be made with water actually boiling when poured from the kettle; should then rapidly be sewed up in a flannel bag previously warmed, and then such bag should be wrapped around, several-fold, with a long flannel strip also previously warmed. A poultice so made will make and maintain for a long time a strongly hot impression (Brunton). No poultices are official in the United States Pharmacopœia.

Powder (Latin, *Pulvis*).—Medicines are often prescribed to be dispensed, and also to be administered, in the condition of powder. Furthermore, the United States Pharmacopœia establishes certain powders of special composition as official preparations. Medicines fit for administration in the condition of powder are ordinarily such as are neither oily on the one hand nor deliquescent on the other, and are neither corrosive, bad-tasting, nor bulky in dose. So far as bad taste is concerned, however, this feature can be neutralized more or less completely by mixing the dose with molasses, honey, or syrup, or by enclosing it in a pulp of apple scraping, or, better yet, for such patients as are old enough to swallow whole a bolus, by encasing the powder in a so-called *capsule* or *wafer*. The *capsules* designed for such purpose are commonly made of jujube paste or some similar material, and consist of a cylindrical chamber, made in two pieces, each open at one end, of which pieces one closely fits into the other, telescope fashion. These capsules are made of several sizes, of capacities to hold from two to four or five grains of a light vegetable powder, dry, or—if moistened so as to pack closer—ten grains. *Wafers* are of two forms. One style consists of two watch-glass shaped bodies, whose edges, upon moistening, will cohere, leaving a central space for enclosure of the powder. The charged wafer is dipped for an instant into water, whereby its surface becomes soft and slippery, when it is to be swallowed immediately whole with a sip of water. The other style consists of a single large, thin, circular sheet of wafer material. Such sheet, dipped into water, becomes flexible, and in such condition is used as a literal *wrap* for the dose of powder.

Resin (Latin, *Resina*).—In the United States Pharmacopœia there are a few preparations bearing the title of *resin* of the respective drug from which they are made. These preparations are obtained by exhausting the crude drug with alcohol, and then precipitating the resulting tincture by the addition of water. The precipitated matter, in these cases, is an impure mixture of resinous principles.

Solution (Latin, *Liquor*).—As a title for preparations official in the United States Pharmacopœia, the word *solution* is applied to such solutions of medicinal principles as do not belong to some technically named class. Concerning aqueous solutions in general, two points present themselves for regard: first, the fact that many substances—even salts, and notably salts of the so-called "organic" acids, citric, tartaric, acetic, and lactic—which may keep indefinitely in the dry condition, will yet spoil quite readily in simple aqueous solution; and *secondly*, the fact that substances soluble in water dissolve therein to very different degrees. In the revision of the United States Pharmacopœia for 1880 the solubilities of the several official chemicals were very carefully redetermined.

Spirit (Latin, *Spiritus*).—In the case of drugs containing active principles at once *volatile* and *soluble in alcohol*, the pharmacy of former days obtained alcoholic solutions of such principles by distilling the crude drug with alcohol. Such distillates were called *spirits* of the respec-

tive drugs from which they were obtained, and the principal drugs so treated for the obtaining of "spirits" were those whose activities resided in a *volatile* or so-called *essential oil*. Alcoholic solutions of volatile oils are still official under the title of *spirits*—constituting, indeed the great majority of official so-called "spirits"; but such spirits are now obtained by direct solution of the previously extracted volatile oil in alcohol instead of by distillation of the crude drug. Such "spirits" of the present United States Pharmacopœia are solutions of the volatile oils of the more fragrant so-called "aromatics," and constitute a fairly distinct class of medicinal preparations. The same are often called *essences*, as, for instance, so-called *essence of peppermint*, and are, as a class strong preparations of their kind, whose dose ranges from a few drops only to not more than a teaspoonful. Besides such spirits of the aromatic herbs, the United States Pharmacopœia entitles as "spirits" the alcoholic solutions, respectively, of *camphor*, of certain volatile *ethereal* bodies, such as ether, chloroform, nitrous ether, etc.; of *ammonia*, of *phosphorus*, of *nitroglycerin*, and also the two distilled liquors *brandy* and *whiskey*. All so-called "spirits," being solutions in alcohol of sufficient concentration, are self-preservative against decomposition.

SUPPOSITORY (Latin, *Suppositorium*).—In common parlance the word *suppository* means a properly shaped plug of medicated material, intended for insertion into the *rectum*, *urethra*, or *vagina*, with the design of having this plug, after insertion, liquefy by the warmth of the part, and so set free a contained medicament. By custom, however, a *urethral* or a *vaginal* suppository is, respectively, so designated specifically, and the word "suppository," unqualified, is held to refer to a *rectal* suppository only. The United States Pharmacopœia, under the title *Suppositoria*, Suppositories, gives a general direction only for the making of a plug intended for use as a *rectal* suppository, leaving it to the prescriber to order the active ingredient to be incorporated with the same. By such pharmacopœial direction, the suppository is made up, in substance, of *oil of theobroma* ("cacao butter"), and weighs "about 1 gm." in the case of rectal and urethral suppositories, and "about 3 gm." in the case of vaginal suppositories. The special medicament is to be mixed with the oil of theobroma, melted by heat, and the mixture then run into elongated cylindrical, conical or globular moulds, according to the kind of suppository. Oil of theobroma is specially adapted for a suppository basis, since it is at once bland, hard at ordinary temperatures but readily liquefied by the temperature of the body, because it combines the qualities of medicinal inertness and hardness at ordinary temperatures with ready capability of liquefaction at the temperature of the rectal cavity. In the administration of a rectal suppository the points should be observed to clean out the rectum before insertion, and, in the inserting, to push the suppository well past the sphincter.

SYRUP (Latin, *Syrupus*).—The title *syrup* is given to such fluid preparations of aqueous basis as contain in solution notable amounts of sugar, the purpose of the sugar being either to flavor or to preserve the preparation. The official "syrups" of the United States Pharmacopœia are quite incongruous. Syrups prepared from *vegetable* drugs are, as a class, of comparatively feeble medicinal power, and are prone to decomposition by fermentation, but, as an offset, are comparatively pleasant of taste. Quite a number of vegetable "syrups," indeed, have no other purpose than to serve as flavoring ingredients. As such may be enumerated the pharmacopœial "syrup," simply so called—an aqueous solution of cane-sugar of specific gravity 1.317, and the "syrups," respectively, of *citric acid*, *almond*, *orange*, *orange flowers*, *wild cherry*, *rose*, *raspberry*, *tolu*, and *ginger*. In prescription a flavoring syrup should, as a rule, not exceed one-half the volume of the prescribed mixture.

TABLET (unofficial).—Recent pharmacy supplies, under the name of *tablet*, a solid disc of small, convenient size, made of some material at once soluble in water and medicinally indifferent; which disc is, in the making, duly charged with a specified dose quantity of some active medicinal substance. These so-called *tablets* are specially convenient for use in hypodermatic medication, a single tablet containing an exact dose of the medicine to be used. For administration by such method, a tablet is taken and dissolved in a few minims of water in a spoon, and then the whole of the extemporaneous solution so made is drawn up into the syringe and injected. Another form of tablet is the *compressed tablet*, consisting simply of the medicine itself, in powder, made into tablet form by powerful pressure. According to the nature of the medicine and its solubilities, compressed tablets may be swallowed whole, like pills, or allowed to disintegrate in the mouth, or be dissolved and taken in potion.

TINCTURE (Latin *Tinctura*).—The word *tincture* applies pre-eminently to the fluid preparations that result from treating vegetable drugs with *alcohol* strong or diluted. Since alcohol is a potent solvent of organic coloring substances, such tinctures are, in the majority of instances, darkly *colored*, whence the name. Tinctures of vegetable and animal drugs form a well-defined class, presenting the following characteristics: 1. They are comparatively *strong*, from the fact that alcohol is, generally, a powerful solvent of medicinal principles. Hence the dose of an organic tincture rarely exceeds a teaspoonful, and may be but a very few drops only. 2. They *keep well*, because of the preservative effect of the alcohol which is their basis. 3. They *taste* less disagreeable than watery preparations of the same drug. 4. Because of their alcohol basis, tinctures deliver in much *smaller drops* than aqueous preparations—a point to be remembered in prescribing the dose of a tincture in drops. 5. Such tinctures as contain resinous bodies, as, for instance, *tincture of myrrh*, will precipitate on admixture with water. Besides the more common tinctures of vegetable drugs, the United States Pharmacopœia establishes, under the title of *tincture*, alcoholic solutions, respectively, of *chloride of iron*, and of *iodine*. The same authority, in its revision for 1880, established a general formula for the making of preparations entitled *Tinctures of Fresh Herbs*, *Tincturæ Herbarum Recentium*. The formula provides for the steeping of one part of a fresh herb in two of alcohol. This pharmacopœial provision is to meet those cases in which a tincture is desired of a vegetable drug whose active principle may volatilize or undergo chemical change through the drying of the drug substance. A disadvantage of these tinctures of fresh herbs is that the strength of any given sample is indeterminate, because of the variable amount of water which different samples of the same herb, when in the fresh condition, may contain.

TRITURATION (Latin, *Trituratio*).—The United States Pharmacopœia of 1880 established under the title *trituration* any mixture of one part of a powdered drug with nine parts of sugar of milk. Triturations are convenient to meet the case of powerful drugs of small dose, when administration in condition of powder is desired. The dose of a trituration of a given drug is, self-evidently, ten times the quantity of the undiluted powdered drug itself. Of drugs likely to be prescribed in trituration, the dose of trituration can commonly be taken dry upon the tongue and swallowed with the help of a gulp of water, all without undue disagreeable taste. From the hardness of the particles of sugar of milk, the drug substance, in a well-made trituration, comes to be very finely subdivided during the process of making, and so is in a condition fit for speedy solution, and hence absorption, when swallowed. Triturations are, therefore, apt to be quicker of medicinal action than other *solid* forms of medicines.

TROCHE (Latin, *Trochiscus*).—The *troche* or *lozenge* is a well-known disc-shaped preparation, consisting of an inert basis impregnated with a proper charge of some medicinal substance, and intended for slow solution in the mouth, commonly for the purpose of medicating directly the mucous surface of the mouth or pharynx. Since slowness of solution is here an obvious desideratum, *tragacanth* is the material commonly taken for the basis of troches. Troches are, generally, weakly medicated and

pleasantly flavored. A number of troches are official in the United States Pharmacopœia.

VINEGAR (Latin, *Acetum*).—*Vinegars* were formerly preparations made by extracting the virtues of a vegetable drug with *vinegar*, but now, though the old title of the preparation is retained, *diluted acetic acid* is used instead of vinegar for the making. Vinegars do not keep so well as tinctures, and are rather superfluous preparations.

WATER (Latin, *Aqua*).—Medicated "waters" were originally the preparations resulting from distilling water from an herb containing an aromatic volatile oil, whence the common name *distilled waters* applied to such preparations. Aqueous solutions of volatile oils still constitute the majority of medicated waters so called, but nowadays, most commonly, the oil previously extracted is dissolved directly in the water, in place of the cruder process of distillation. The aromatic waters form a well-defined class of drugs, characterized especially by the feebleness of their medicinal activity, due to the very slight solubility of volatile oils in water. Hence the dose of an aromatic water is commonly at least a tablespoonful, and many of such waters are only of service as pleasantly flavored aqueous bases for extemporaneously prescribed fluid mixtures. The aromatic waters of the United States Pharmacopœia are those, severally, of *bitter almond, anise, orange flowers, cinnamon, fennel, peppermint, spearmint,* and *rose.* Besides these aromatic waters, the United States Pharmacopœia establishes under the title *waters*, aqueous solutions, respectively of *camphor, creosote, ammonia, chloroform, hydrogen dioxide,* and *chlorine*—substances, it may be noted, all *volatile,* like the aromatic oils.

WINE (Latin, *Vinum*).—Medicated wines consist of a medicine in solution in white wine, or of a tincture of a vegetable drug diluted with white wine. Medicated wines are of comparatively poor keeping qualities, and, generally speaking, are not very eligible preparations.

Edward Curtis.

[1] Stelwagon: American Journal of the Medical Sciences, October, 1885.

MELÆNA NEONATORUM. See *Hæmophilia.*

MELANIN. See *Coloring Matters, Animal.*

MELANOMA. See *Sarcoma.*

MELANOSIS. See *Addison's Disease,* and *Sarcoma.*

MELROSE SPRING.—Blount County, Tennessee.

POST-OFFICE.—Maryville. Hotel (seventy-five guests).

ACCESS.—From Knoxville viâ Southern Railroad (Knoxville and Augusta branch) to Maryville, thence eight miles by stage to springs. This resort is located among the picturesque mountains, at an elevation of 1,500 feet above the sea-level. It is kept open from May 15th to the end of October. The springs are four in number, No. 1 being known as the "Chalybeate," and No. 2 as the "Yellow Sulphur," while the last two are freestone springs, with no special medicinal properties. No analysis has been made, but the chalybeate water is said to be one of the best and strongest in the State. In addition to its internal use, it is used locally for its astringent effects.

James K. Crook.

MÈNIÈRE'S DISEASE. See *Auditory Nerve, etc.*

MENINGITIS. See *Brain: Simple Meningitis.*

MENOPAUSE. See *Change of Life.*

MENORRHAGIA.—This term signifies an excessive loss of blood at the time of the monthly period. The blood may be discharged from the uterus alone, or it may proceed from one of the other openings of the body, from the mouth, nose, or anus, or it may appear upon the skin in the form of numerous spots or petechiæ which may be no larger than a pin's head or may be as large as a five-cent piece. This latter variety is sometimes known as *vicarious menstruation,* which seems to me a bad term, and I have substituted the term atopomenorrhœa (ἄτοπος, out of place, μῆνος, by the month, monthly, ῥοία a flowing or discharge, from ῥεῖν to flow).

This form of hemorrhage has many elements in common with that which is known as metrorrhagia, and the reader is referred to the article under that heading for a comparison of the two conditions.

The simplest or typical form of menorrhagia is that which occurs merely as an exaggerated form of the customary monthly flow. It also occurs as an occasional accompaniment of the menopause or the impending menopause, as the result of disease of the endometrium, as the result of displacement of the uterus, as the result of pregnancy, as the result of neoplasms of the uterus, as the result of acute or chronic general disease, and as the result of change of residence.

In all these varieties of menorrhagia we must remember that the underlying cause is the disturbance of an exceedingly sensitive function which is characterized by the monthly recurrence of congestion of the pelvic circulation with a decided increase in the tension of the blood-vessels.

1. In the *simplest form of menorrhagia* we may have a great increase in the quantity of blood lost during the usual number of days of menstruation, or the duration of the flow may exceed the usual number of days, the quantity lost on each day not being much greater than is customary during an average menstruation. It may be unaccompanied with pain, its principal symptoms being the annoyance attending the prolonged use of the napkin and the weakness from an excessive loss of blood. The cause for this irregularity may be entirely obscure, it may be a peculiarity of an individual or family, and it may be impossible to trace it to any disease, either local or general. It may be continued for months and years, and it may make no apparent inroads upon the patient's health, if she is of a robust constitution, or it may result in constant anæmia and weakness. It does not seem to me wise to allow such a condition to continue, and it has always been my practice to advise that measures be taken to remedy it.

The treatment of this condition is not usually difficult. An examination of the patient should be made in the dorsal position; a bivalve speculum having been introduced into the vagina, the condition of the portio vaginalis is determined by ocular inspection. If the os is eroded and granular and the lips are everted, this may be the source of the trouble and is to be remedied by the operation of trachelorrhaphy. A probe or a small dull curette should then be introduced into the uterus and gently drawn over every portion of the endometrium. If the latter is unduly soft or if bleeding is excited a curettage will be indicated. If none of these symptoms is present and there is no evidence of disease in the uterine appendages, I have usually found it good practice to make applications of Churchill's tincture of iodine or a strong solution of nitrate of silver to the interior of the uterus two or three times a week, except during the menstrual period. Such treatment may be necessary for a period of two or three months. If the patient is very anæmic, it will sometimes be found useful to plug the uterine canal during menstruation, thus checking the flow mechanically. The patient should be kept in bed during the period of menstruation and a tonic of some approved preparation of iron, or strychnine, or cinchona administered until the strength is restored.

2. In the *menorrhagia which occurs during or just before the menopause* we usually have a decided hypertrophy of the endometrium, and this may be the case whether the menstruation continues after monthly intervals or after longer and irregular ones. The hemorrhage in such cases is often profuse and alarming, and it is neither good practice nor common sense to dismiss the matter with the opinion that it is the change of life and that therefore one must wait until it is over. The condition of the endometrium must be determined by careful examination. As a rule the operation of curettage with the sharp curette

will be indicated, and this must be repeated should the hemorrhages recur, as they not infrequently do after the lapse of six months or a year. It is a useless waste of time to treat such cases by the internal administration of drugs, and the application of astringent or caustic substances to the endometrium is only a trifle better.

3. *Menorrhagia from Disease of the Endometrium.*—This is in distinction, of course, from the conditions which have been described, for the endometrium may be the seat of disease apart from the menopause, and there are many conditions which may cause such disease. One of the most frequent of such causes is gonorrhœa, by which an acute or a chronic inflammation may be produced. The inflammation of the endometrium is but an incident in the history of the disease, for when that tissue has been invaded other tissues have already been attacked. It is not pertinent to this article to refer to the other symptoms, the excessive bleeding with the monthly flow alone concerns us. The menorrhagia may be present with only one monthly sickness, or it may be repeated with an indefinite number of them, especially if the infectious elements of the disease progress to the uterine appendages and the peritoneum. Also when the appendages are affected with other diseases of an inflammatory nature the endometrium may be inflamed and menorrhagia be one of the consequences. Such inflammations are usually, perhaps always, of an infective character, and though the infection usually progresses from the endometrium to the appendages, the menorrhagia appearing after the appendages have become diseased, it may also proceed from the opposite direction, inflammation passing from the peritoneum to the appendages, and thence to the endometrium, and menorrhagia resulting. The hemorrhage in such cases may be of long duration; it usually ceases if the diseased appendages are removed, and it may continue for many months if such an operation is not performed. Curettage of the endometrium in such cases is only a palliative measure, the hemorrhage recurring for as long a time as disturbance in the appendages persists. Menorrhagia also results when the endometrium is diseased as the consequence of masturbation or excessive sexual intercourse. Prostitutes are especially subject to this form of hemorrhage, although it is a fact that in such cases the uterine appendages are usually the seat of gonorrhœal disease.

4. *Menorrhagia due to Displacement of the Uterus.*—This condition arises from a disturbance of the pelvic circulation caused by the unnatural relations resulting from the displacement, stasis and overfilling of the veins being noteworthy symptoms. It is unnecessary to say that menorrhagia does not occur with all cases of displacement. The only variety with which it is at all frequent is the retrodisplacement. With retroversion it is less common than with retroflexion. The more complete the retroflexion the greater the disturbance of the circulation and the more probable the occurrence of menorrhagia. Hypertrophy of the endometrium frequently results, and it is not unusual that the physician is obliged to resort to curettage in order to afford the patient the desired relief. This relief, however, is apt to be only temporary. The only permanent relief is that which follows secure replacement of the organ by operative procedure with consequent restoration of the normal conditions of the circulation.

5. *Menorrhagia Resulting from or coexisting with Pregnancy.*—It is not an unusual occurrence that a monthly loss of blood should persist during a portion of the period of pregnancy, or even during the entire period. This phenomenon has been explained by the assumption that in these particular instances the uterus has kept up the menstrual habit. While this explanation may occasionally be a valid one, it is more reasonable to believe that in such cases the endometrium, especially that of the cervix, is diseased or at any rate is so greatly congested that it finds relief in this manner. There is also the hemorrhage which arises with the vicious implantation of the placenta, known as placenta prævia, which occurs during the later months of pregnancy, but which may deceive one by its occurrence at the time when menstruation was expected to make its appearance. It is needless to say that in all these cases a careful examination must be made, and it will usually be desirable to tampon the vagina to check the bleeding. The uterus should not be tamponed except as a last resort, for it will result in the dilatation of the soft uterine tissues, the production of contractions, and the expulsion of the uterine contents.

6. *Menorrhagia due to Neoplasms of the Uterus or of the Abdominal Viscera.*—A number of conditions produce this form of menorrhagia: myomata of the uterus, especially the submucous and intramural varieties; carcinoma of the uterus, especially that form which first invades the corpus; sarcoma of the uterus, tuberculosis of the peritoneum, carcinoma of the intestine, or of any of the abdominal viscera. The result in all these cases is a highly congested condition of the uterus with more or less hypertrophy of the endometrium, and the monthly period is characterized by an excessive loss of blood. The bleeding may not be limited to this periodical function, but may recur at irregular intervals, being then denominated metrorrhagia. The treatment for this condition is at best only palliative. Curettage of the endometrium may check the bleeding for a time, but it will soon recur. The removal of the source of the trouble will alone produce radical results. With the benign diseases such an operation is most desirable; with the malignant diseases, especially those in which great areas of tissue are involved, a radical removal is usually impossible.

7. *Menorrhagia from some Acute or Chronic General Disease, including the Nervous Diseases.*—In the case of some of the general diseases the menses are unaffected. Even in the severe forms of paralysis we often see little variation from the normal. In hysteria, on the other hand, the uterus may be congested, and it is also likely to be so in acute and chronic diseases of the kidneys, liver, peritoneum, etc., in anæmia, tuberculosis, and syphilis, and probably in certain cases of continued fever or of intermittent fever.

The treatment consists mainly in the treatment of the underlying cause. Occasionally curettage or the tamponade of the vagina will, be efficacious, but such treatment fails to strike at the root of the disease.

8. *Menorrhagia from Change of Residence.*—This implies, of course, a change in the blood tension such as results when one removes to an altitude several thousand feet higher than that to which one is accustomed. Hemorrhage of this variety is usually not alarming and subsides when the equilibrium of forces has been re-established, *i.e.*, when the patient becomes habituated to the new conditions. There is scarcely any occasion for treatment in such cases or for comment upon that phase of the subject. Finally, a few words should be said concerning the vicious hemorrhage which occurs in unusual or unaccustomed parts of the body (atopomenorrhœa), either coincidently with the monthly hemorrhage or in place of it. The fundamental consideration, of course, is that during menstruation there is an increase in the blood pressure. If, for any reason, the resistance in the uterine vessels is too great to permit adequate relief for this pressure, the blood current will necessarily be diverted to other parts where the resistance is less. Such a part may be the mucous membrane of the anus, the stomach, the nose, or the mouth, or the blood may transude through the capillaries of the skin. The loss of blood in such cases may be considerable and always calls for an examination of the uterus. It may be that no anatomical fault in the uterus can be discovered, or there may be a flexion in the organ which can be relieved by appropriate measures. In some cases such a diseased condition of the blood or of the blood-vessels exists that the hemorrhage can be attributed to this cause, its occurrence during menstruation being only incidental.

Andrew F. Currier.

MENSES, RETENTION OF THE.—The menstrual flow, menstruation, or the menses, signifies the discharge from the uterus of blood, epithelium, and mucus, an oc-

currence which takes places normally in every woman during the child-bearing period, that is, from puberty until the menopause, unless there is some bar or hindrance which prevents such an occurrence. The expression "retention of the menses" indicates or implies that there is an attempt on the part of nature to accomplish this function, but that it is rendered ineffective from one cause or another.

It is necessary to differentiate this condition from that in which the menses fail to appear, the blood failing to flow from the uterus by reason of some cause, physiological or pathological, which prevents such an occurrence. Such a condition is known as amenorrhœa. An example of the physiological absence of menstruation is to be found in pregnancy. Should menstruation take place during pregnancy it would be abnormal and would require investigation to ascertain its cause. An example of the pathological absence of menstruation exists in the wasting diseases, such as tuberculosis, in which the body has no blood to spare, nature taking this means of cutting off one of the avenues by which vital force is dissipated.

When there is true retention of the menstrual blood nature is endeavoring to perform her usual function, but a hindrance is offered and the design of nature is thwarted. The causes of this condition are few in number and are perfectly well known. They are entirely of a mechanical nature. They may be located at the vulva, within the vagina, at the os uteri, or within the uterine canal. The obstruction may be complete or partial; that is, the avenue of exit for the blood may be entirely closed so that not a drop of blood will escape, or a slight opening may be present so that when the tension and pressure are sufficiently great a small quantity of blood will find its way out, the greater portion, however, being retained within the vagina or uterus or both.

At the vulva the obstruction consists in an impervious condition of the hymen, which may be thick and fleshy or thin and membranous. When the accumulation of blood within the vagina and uterus is considerable, the pressure upon the hymen is usually sufficient to convert it into a thin membrane and it may even bulge outward from the vulva. In some cases it may rupture, thus effecting a spontaneous cure for the condition.

The obstruction may also be at some point within the vagina. It may be in the form of a membranous septum crossing the vagina from side to side, or diagonally from the os uteri to the vulva. Such septa are due to faults of development during the fœtal period of existence and are of quite rare occurrence. An obstruction of this character might cause either complete or partial retention of the menstrual blood. Obstruction in the vagina might also be due to the presence of a fibroid tumor proceeding from the uterus and gradually filling the entire vagina. Such an obstruction is as effectual a plug to the escape of fluids from the uterus and vagina as is a cork in a bottle. It is quite possible in such cases for the blood to be shed by the uterine mucous membrane, but it is quite impossible for it to get out. The fibroid tumors or polypi in question are prone to spring from the lower portion of the uterus, or even from the cervical canal, so that quite a cavity may remain above their origin for the accumulation of menstrual blood. The obstruction may also be at the os uteri or within the uterine canal. That which is within the uterine canal has already been alluded to in referring to the fibroid tumors which may fill the vagina.

Of course, it is quite possible that the tumor may not encroach upon the vagina to a great extent. It may fill the lower portion of the uterine canal, and may include the cervical canal, in either case preventing the exit of menstrual blood; or the blood may escape slowly and with difficulty, more or less of it remaining above the tumor in the cavity of the uterus. The uterus may also be effectually plugged by the presence of a membranous tissue over the os uteri, the blood accumulating within the uterine cavity and possibly regurgitating into the Fallopian tubes and peritoneal cavity. Finally, the obstruction may consist of a complete absence of the vagina, the development of the genital organs having been defective in this respect, though in all other particulars they may be normal. In such cases there is no possible means of escape for the menstrual blood, and it must accumulate within the cavity of the uterus.

Clinical History.—In any case of obstruction from such causes as have been mentioned the ordinary symptoms which accompany menstruation, called menstrual molimina, apart from the discharge of blood, are usually present. Such symptoms are backache, bearing-down pain, headache, etc., and they may occur with as great regularity as in ordinary menstruation. As the quantity of blood increases, the pain in the abdomen and pelvis may be very severe, and it is quite possible that peritonitis may result either from the blood which finds its way into the peritoneal cavity or from some injury which may be received from without. The vagina may become greatly distended, and the uterus may become enlarged so that a very perceptible abdominal tumor is present. I have seen a uterine tumor of this variety which extended to the umbilicus. Nausea, vomiting, and constipation are also symptoms which are pronounced and troublesome; the bladder may become irritable and the desire to pass urine may be persistent and annoying. Except for the possibility of peritonitis the general health is seldom greatly disturbed, and during the intervals between the recurring attempts at menstruation the patient may be in a very fair state of health. It is hardly necessary to say that this condition usually occurs in very young women. Should it occur in those who have borne children (I have seen one such case), it is usually due to an injury received during parturition, the uterus or vagina being sealed as the result of the ensuing inflammation.

Treatment.—There is but one successful mode of treating this condition, apart from the very rare spontaneous cure which may result from the rupture of the offending obstruction, and that consists in freely opening the tissues which have caused the obstruction and evacuating the retained fluid.

The patient should be placed in the lithotomy position with the hips raised three or four inches higher than the remainder of the body. The pubes should be shaved and thoroughly scrubbed with a 1 to 5,000 bichloride-of-mercury solution, alcohol being then poured liberally over the entire surface. If the obstruction is at the vulva, it is then pierced with a trocar and the retained fluid slowly drawn off through a cannula. The vulvar orifice is then dilated with a steel dilator, a double-current catheter is introduced into the uterus, and both this cavity and the uterus and vagina are irrigated with a hot 1 to 5,000 bichloride-of-mercury solution, the irrigation being continued until the water returns perfectly clear. A strip of five-per-cent. iodoform gauze is then introduced into the uterus as a drain, but *not as a tampon*, and another into the vagina. This must be renewed daily until all discharge has ceased. The patient must be kept quiet in bed for at least a week, for not until this period of time has elapsed will the dangers of sepsis and peritonitis have passed. The bowels should be opened daily, an enema of half an ounce of sulphate of magnesia in a pint of hot water being used if necessary. If the membranous obstruction is within the vagina or at the os uteri, the treatment should be the same as when it is at the vulva.

If the obstruction consists of a tumor in the vagina or uterus, the spot from which it originates must be reached, the tumor removed, and the uterus and vagina irrigated as already described.

If the tumor fills the vagina, it may be necessary to deliver it with obstetric forceps before the pedicle can be reached. It may also be necessary to divide the cervix on either side in order to get at the pedicle. The pedicle may be cut with strong scissors or with the thermocautery. It may also be removed with the wire écraseur. The conditions in a given case will govern the mode of removal. If the cervix has been divided, a suitable number of interrupted chromicized catgut sutures must be used to close the wounds after the tumor has been removed. In the rare cases in which there is congenital absence of the vagina or in which the vagina has become

closed as the result of an inflammatory process, the tissues must be torn or cut until the uterus is reached when the latter may be opened with a trocar, or, if possible, with a steel dilator. It is very important in doing such an operation that a finger be constantly kept in the rectum as a guide to the proper direction of the knife or scissors. With the improved methods of operating which are now in vogue such operations can be performed with a minimum of danger, whereas in former years the danger of septic infection and even of fatal peritonitis was considerable. *Andrew F. Currier.*

MENSTRUATION.—INTRODUCTORY.—The period during which a girl passes from childhood to young womanhood is a comparatively extended one, and brings about many changes. According to recent literature the term *puberty* is given to the initial period of development of the reproductive organs, while to the whole term, from the beginning to the completion of the reproductive function, is applied the broader term, *adolescence.*

The changes which take place during puberty are marked by both external and internal manifestations; by both physical and mental development. The outer physical signs are the swelling of the breasts, the widening of the pelvis, the enlargement of the thighs, and the growth of hair upon the pubes. The mental development is characterized by the desire for change, the longing to accomplish something, the oncoming of doubts, and the general assertion of individuality. The inner physical change consists in the growth and development of the two organs essential to woman, namely, the ovary and the uterus. With this development come the functions of ovulation and menstruation.

OVULATION.—Under ovulation let us consider the phenomena which take place in the ovary and which include the maturing of the ovum, the bursting of the vesicle which contains it, and the departure and migration of the ovum.

The Graafian vesicles, which until puberty form a uniform, smooth layer in the ovary, begin with the development of this organ to assume a different appearance. Instead of growing uniformly as before, a few of the vesicles make a much more rapid growth than the others, and finally one becomes even more active than these and develops until it reaches the size of a hazelnut and has forced itself through the ovigenetic layer to the epithelial surface. With the distention of the vesicle the walls become thinner and finally burst, liberating the ovum which is forced into the pavilion of the Fallopian tube. The tube being applied to the vesicle at the moment of its bursting, the ovum when expelled enters the pavilion and is carried by the tube to the uterus by a continuous current of serous fluid set up by the cilia which line the tube and by the peristaltic contractions of the tube itself. If for any reason the ovum when expelled does not enter the pavilion, it enters the abdominal cavity and is lost; or, if fertilized, it may cause extra-uterine pregnancy. The journey from the pavilion of the Fallopian tube to the uterus occupies from twelve to fifteen days. Ovulation may or may not be coincident with menstruation; while it is usually so, instances of intermenstrual ovulation are not unknown. However, ovulation begins with puberty and ends with the menopause, being probably suspended during pregnancy and lactation, although the not infrequent cases of pregnancy occurring during lactation would seem to disprove the latter. The two ovaries supply the ova alternately, excepting in occasional instances when one ovary may furnish several successively. Although ovulation is spontaneous and results from a congestion in the Graafian follicles, it may be affected and augmented by the presence of the male and may be precipitated by copulation.

MENSTRUATION.—Menstruation is a periodic discharge of blood from the uterus and Fallopian tubes. It is periodic, occurring every twenty-eight days (or, according to Dubois and Courty, thirty days), and lasting only during the term of a woman's sexual activity, *i.e.*, from puberty to the menopause.

The child-bearing period may be divided into menstrual cycles, each of which is subdivided into periods each occupying a given portion of the cycle and each following the other in regular sequence. Marshall names these stages the constructive, destructive, reparative, and quiescent stages.

1. The Constructive Stage. During this stage the uterus is prepared for the reception of the ovum by a swelling of the mucous membrane. This swelling is caused by a growth of the connective tissue and a filling up of the veins and capillaries with blood. Just why the mucous membrane swells in this way is not known, but the swelling is so marked that it doubles or trebles the thickness of the membrane. Then by a diapedesis through the capillaries, perhaps assisted by a bursting of the capillary walls, blood passes into the connective-tissue spaces below the mucosa. The mucous membrane becomes thick, swollen, dark in color, and very soft, and the uterine glands are lengthened. The superficial layer remains for the most part intact. A fatty degeneration of the epithelium follows the diapedesis and with the bursting of the capillaries the blood and epithelial cells pass out. This stage occupies about a week, and when conception does not occur is followed by the second stage.

2. The Destructive Stage. This stage is the result of the active changes of the constructive period. During this time the degenerated material is carried off and brings about the menstrual flow. After five days the third stage follows.

3. The Reparative Stage. Now sets in the reparation of tissue broken down by the previous stages. This is done by a process of growth from below and continues for about four days.

4. The Quiescent Stage. This is the period of rest occupying the remaining twelve or fourteen days of the cycle.

The Theory of Menstruation.—Just what causes the phenomenon of menstruation is not definitely decided, but that there is a positive relation between ovulation and menstruation can scarcely be doubted. Sigismund, Löwenhardt, and Reichert believed that menstruation occurred because the ovum just previously discharged had not been impregnated and, therefore, the uterine mucosa could not continue its development; instead, it underwent degeneration, accompanied by bleeding from the mucosa. Hirst attributes menstruation to a nervous influence proceeding from the sympathetic ganglia in the lower abdomen stimulating and congesting the sexual organs. Jewett names ovulation as the cause of menstruation. Pflüger considers that the "constant growth of the ovarian cells and the consequent swelling of the ovary subject the ovarian nerve fibres, and through them the spinal cord, to a constant slight stimulation. Through the summation of the stimuli within the cord a reflex dilatation of the vessels in the genital organs is produced; the excessive blood supply leads in turn to a tumefaction of the uterus and frequently to the ripening of a Graafian follicle. Bleeding follows, and at the same time, or slightly later, the rupture of the follicle occurs. The menstrual flow and ovulation are therefore two phenomena conditioned by the same cause, namely, the menstrual congestion, yet either may occur without the other." Most recent writers agree that ovulation and menstruation are in the main independent and may or may not occur simultaneously; that the growth of the uterus and its mucosa is a preparation for the reception of the fertilized ovum. If an ovum is fertilized and carried to the uterus, it attaches itself to the inner wall, usually near the fundus; pregnancy follows and the mucosa is not shed. If, however, fertilization is not accomplished, the decidua is shed as the decidua menstrualis in the menstruation which follows.

Inasmuch as the uterus during the constructive stage is best prepared to receive the ovum, it cannot be for the ovum discharged at the time of the accompanying menstruation, as it requires at least a week for the passage of the ovum from the ovary to the uterus. Marshall and

others conclude that menstruation relates to an ovum discharged from the Graafian follicle at the preceding period rather than to that of the same period.

First Appearance of Menstruation.—The catamenial flow is not in general of sudden appearance, but is prefaced by a monthly swelling and tenderness of the breasts, a feeling of general lassitude and headache, usually accompanied by a white mucous discharge. The actual establishment of menstruation may not take place for several months after the first symptoms and may even then be irregular, appearing one month and failing for several, then reappearing. This is not abnormal. After the thorough establishment of the function, its failure to occur marks either pregnancy or a pathological condition.

The symptoms preliminary to menstruation may be observed as early as the tenth year of age, and the menses proper may appear between the ages of twelve and sixteen,—the average age being fourteen years. It is not unusual, however, to find cases of earlier menstruation or to find it delayed to the twentieth or even to the twenty-fifth year.

The time of the first appearance of the menstrual flow is influenced by race, climate, social conditions, and hereditary and individual peculiarities. In general, girls in warm climates menstruate earlier than those in cold climates, and those of the city earlier than girls of the country; while laboring women menstruate earlier in life than women of the leisure class. Any condition which excites the genital instinct hastens the time of menstruation. Hirst states that in Hungary, the three races—Slavonic, Magyar, and Jewish races—living in the same climate, menstruate at respectively sixteen, fifteen, and thirteen years of age. The girls of Lapland menstruate at eighteen, while in those of Egypt the function is established at the age of ten years.

Menstrual Symptoms.—Menstruation is accompanied by certain local and reflex symptoms. For one or two days previous to menstruation the individual feels a special sensitiveness and nervous excitation accompanied by headache and a general feeling of fulness in the abdomen, all of which symptoms are relieved by the beginning of the flow.

Owing to the increased weight of the uterus and its congested condition, a feeling of weight and pressure is experienced in the pelvic region during the flow. During the first few days of the period women are likely to be nervously sensitive to noise and worry, and predisposed to mental depression. Women of hysterical or epileptic tendency are liable to outbreaks at this time if at no other. The skin shows a greater degree of pigmentation, noticeable in the discoloration about the eyes and blotches upon the face. The skin also becomes congested and may break out into pimples and fever sores.

A not infrequent accompaniment of the catamenial flow is turgescence of the breasts, swelling of the thyroid and parotid glands and tonsils. There is indeed a profound physiological change of which the uterine condition seems to be but a part. According to Hirst the temperature is higher by 0.5° C., while the observations of Giles seem to indicate that the maximum temperature is attained two days before menstruation, followed by a sudden drop on the day preceding the flow.

Character of the Discharge.—There are three distinct stages of the flow during each of which the character of the flow shows certain peculiarities. The first discharge is composed of blood largely mixed with mucus, which gives it a slimy consistence. It contains also epithelial cells from the broken-down membrane of the uterus and tube, together with a glandular discharge, and possesses a strong odor. During the second stage the blood is almost pure, being brighter in color and very slightly slimy. The third stage is marked by the smaller number of blood globules, the reappearance of mucus, and the absence of epithelial cells. Occasionally a woman will have a discharge of almost pure blood following the third stage, but this is unusual.

Menstrual blood is alkaline in reaction, dark in color, and should not clot.

Quantity and Duration of Discharge.—It is difficult to measure accurately the amount of fluid discharged during the menses. It is estimated variously by different authorities at from four to six ounces; from three to eighteen ounces; and from four to eight ounces. From these varying quantities it is safe to conclude that the average monthly discharge is from five to six ounces. The quantity is more usually measured by physicians by the number of napkins, more than three napkins a day being considered excessive.

There is considerable variation in the duration of the flow. In some women it does not exceed two days, in others four, while in a large number it lasts five, six, or even seven days. Ordinarily it lasts from three to six days, varying with the individual. The greatest amount of blood is lost during the first three days, the quantity then gradually decreasing until it ceases entirely.

Cessation of Discharge.—The period of menstruation extends over about thirty years, varying greatly in individuals. As the age of puberty may be any time from ten to twenty, so the menopause may be any time from thirty to eighty. These are, however, extreme figures, the average being between forty-five and fifty. Women who menstruate early are likely to reach their climacteric late; while those who mature late will probably cease to menstruate early. The cessation, like the establishment of menstruation, is in general a gradual change. The first symptom of the menopause is an irregularity of the flow. It may cease for a few months and be followed by several months of regularity, when it may again cease. The irregularity of the occurrence of the menstrual flow may extend over six, nine, or twelve months until the final cessation. There is also usually an irregularity in the duration of the periods and in the quantity of the menstrual discharge at the different periods. The most marked symptoms of the menopause are the accompanying congestion of other than the genital organs, namely, the head, liver, and lungs. Women complain of dizziness, flashes of heat, and mental depression. The sexual life seems to be especially active just before the cessation of the menstrual flow, and it is not uncommon for women who have not conceived for years to become pregnant at this time.

With the cessation of the flow there is an atrophy of the genital organs. First the ovary, then the uterus decreases in size and atrophies, sometimes disappearing entirely. The labia majora lose their fulness, the hair of the pubes turns white and falls, the breasts shrivel, and the individual loses those physical characteristics which are essentially feminine.

It is possible for menstruation to be regular through an entire pregnancy, but this is very unusual.

Comparative Physiology.—For years it was thought that the menstrual function was one peculiar to the human female and that its counterpart did not exist in the lower animal world. So long as this hypothesis was accepted, it was difficult to account for this function in women. All important observations along this line in recent years point to the fact that menstruation is but the analogue of "rut" or "heat" in the female of the lower animals. With this difficulty settled, there is no more mystery regarding the necessity for this function, and we have to deal simply with a highly developed reproductive phenomenon inherited from the remote ancestors of man.

In the lower animals in their native state there are certain breeding seasons specially favorable to reproduction, the season varying with the latitude. Domestication has made many changes in the sexual habits of the lower animals, which now have more frequent periods of reproductive activity. The lower the animal in the scale of life, the fewer are the points of resemblance between the "heat" and menstruation, and conversely, the higher in rank the more numerous are the likenesses between the two. In the domestic monkey, cow, mare, buffalo, zebra, and hippopotamus, if impregnation be prevented, the

periods of "heat" occur with regularity, at intervals of four weeks. During these periods the animals show a nervous excitability, a swelling of the genital organs, a desire for copulation, and a uterine discharge. This discharge is scanty, contains mucus and blood, and the proportion of blood increases as the scale of animal life is ascended.

In dogs the phenomenon is quite similar to that of the human female. There is the same congestion of the uterine mucous membrane and the same rupture of the capillaries, but it is thought that the epithelium is not actually shed. In monkeys the process is still more like the human menstruation. Heape, in his observations upon monkeys, has found that some monkeys menstruate during the non-breeding period. He calls attention also to the fact that in far northern countries women do not menstruate during the winter months.

It has also been shown that while there is now no special breeding season among human beings, there is still in general a greater tendency to fecundity in the spring. According to statistics the largest number of human births falls in February following conceptions in May and June. The largest number of conceptions in Sweden occur in June; in Holland and France they occur in May and June; while in Greece the greatest number of conceptions falls in April.

As we travel south the spring is earlier and the greatest number of conceptions is also earlier.

The large amount of blood in the menstrual flow has been accounted for in part by social and marital conditions and largely by the erect position assumed by the human species.

The Relation of Menstruation to Lactation.—During the congestive period of menstruation, a change is noticed in the mammary glands of many nulliparous women. The nipple becomes erected and congested, secreting a yellowish discharge, the area surrounding the areole darkens and the veins become prominent. Frequently the condition is scarcely if at all to be distinguished from that of the breasts of pregnant women during the first three months.

Menstruation is usually re-established in primiparæ about the sixth month after delivery. During the second lactation it reappears about the eighth or twelfth month, and during the third or fourth lactation menstruation seldom occurs. The recurrence of menstruation does not necessarily suggest a cessation of nursing, although the quality of the milk is sometimes impaired.

Jeannette Winter Hall.

MENTHIODOL is a mixture of four parts of menthol with one of iodol, fused together and moulded into cones and sticks. It is rubbed over a neuralgic area, or on the forehead for headache. *W. A. Bastedo.*

MENTHOL.—($C_{10}H_{19}OH$). A stearopten (having the characters of a secondary alcohol) obtained from the official oil of peppermint, or from Japanese or Chinese oil of peppermint (from *Mentha arvensis* De C., vars. *piperascens* and *glabrata* Holmes). It is separated from these oils by the action of cold. The enormous extent to which this substance has been adulterated renders attention to the following official description a matter of importance.

Colorless, acicular, or prismatic crystals, having a strong and pure odor of peppermint, and a warm, aromatic taste, followed by a sensation of cold, when air is drawn into the mouth.

Menthol is only slightly soluble in water, but imparts to the latter its odor and taste. It is freely soluble in alcohol, ether, chloroform, carbon disulphide, or glacial acetic acid.

It melts at 43° C. (109.4° F.) to a colorless liquid, boils at 212° C. (413.6° F.), and volatilizes slowly at the ordinary temperature.

When it is triturated with about an equal weight of camphor, thymol, or chloral hydrate, the mixture becomes liquid.

Its alcoholic solution is neutral to litmus paper, and deviates polarized light to the left.

If a little menthol be heated in an open capsule, on a water-bath, it should gradually volatilize without leaving any residue (absence of *wax, paraffin*, or *inorganic substances*).

If a few crystals of menthol be dissolved in 1 c.c. of glacial acetic acid, and then three drops of sulphuric acid and one drop of nitric acid be added, no green color should be produced (absence of *thymol*).

Most of the menthol of commerce is the Japanese variety. The surface is usually moistened with retained oil. When brought in contact with the tissues it acts as a local vascular stimulant and produces a sensation of heat and burning. When its application is prolonged, it deadens the sensibility of the nerve terminals and acts as an anæsthetic. This local effect may be very marked but it does not produce any corrosive action. When administered internally it is a diffusible stimulant, increasing the vascularity and tone of the mucous membrane. Its stimulant action extends to the general circulation, increasing the force of the heart's action and improving the vascular tension. Menthol is also an active antiseptic, but is not available for ordinary use on account of its insolubility in water.

As a local application menthol is of service in neuralgia, myalgia, pruritus, and other painful affections. It may be applied in its pure state in the form of cones; or as an ethereal or alcoholic solution, in strength varying from ten to fifty per cent. Its combinations with other analgesics, as chloral and camphor, are very valuable for all superficial neuralgias.

It is rarely administered internally except for its local stimulating and antiseptic action upon the stomach and intestines. It has been given for atonic conditions accompanied by much flatulence. As an anti-emetic it has been recommended particularly in the vomiting of pregnancy. The dose for internal use is from half a grain to three grains, which may be administered in cachets, or in solution in oil or spirits. The following combinations form a permanent mixture: menthol, ʒ ij.; alcohol, ℥ i.; glycerin, ℥ i.; syrup, ℥ i.

Menthol has received much attention in the treatment of nasal and pulmonary affections, on account of its local action. A few crystals warmed in a vessel may be inhaled, or a few drops of a concentrated solution may be evaporated and inhaled. Eucalyptol, thymol, resorcin, and many similar drugs may be combined. As it vaporizes at 109° F. it is easily employed by means of an inhaler placed in hot water. Solutions in oil or ether may be applied directly to the mucous membrane of the nose or throat. In this way it has been recommended in hay fever and in laryngeal phthisis. A five- or ten-per-cent. solution should be commenced with. In pulmonary phthisis its intratracheal use has been adopted, one drachm of a ten- or twelve-per-cent. solution in oil being introduced into the trachea twice daily. Its application has also been advised in the treatment of diphtheria.

Beaumont Small.

MENTHOL-IODOL is iodol containing one per cent. of menthol. *W. A. Bastedo.*

MENTHOPHENOL is a thick, transparent fluid made by triturating one part of phenol with three parts of menthol. It is an antiseptic, and locally somewhat anæsthetic to ulcers and burns, and has been used as a counter-irritant. Fifteen drops in a glass of warm water makes an antiseptic wet dressing or mouth wash.

W. A. Bastedo.

MENTONE (MENTON), FRANCE.—Of the famed winter health resorts of the beautiful Western Riviera, Mentone is perhaps the most typical as well as one of the most attractive. It is five miles east of Monaco and fifteen (by rail) from Nice. Like all the Riviera resorts, Mentone consists of a narrow strip of land on the coast shut in by encircling mountains, rising higher and higher

as they recede from the sea. It occupies the projecting central point of a shallow bay formed by Cap S. Martin, on the west, and Cap de la Murtola, or Mortola Point, on the east. "From cape to cape this bay is about four miles across, and has a southeasterly aspect." The projecting ridge upon which the town is built divides this bay into two lesser bays, the east, which is the smaller, and the west. The climatic characteristics of these two portions of Mentone, the east and the west bays, differ materially, principally on account of the position of the mountains. In the eastern bay portion the mountains and hills come very close to the shore, leaving scarcely any room for the town, which "consists of little more than a road and a row of houses and hotels squeezed in between the base of the mountains and the seashore." Moreover, there are no considerable valleys, bringing cool air down from the mountains, as is the case in the western bay portion. In consequence of this topographical difference the temperature of the east bay is several degrees higher than that of the western bay. In this latter portion the mountain wall is about three miles distant from the town, permitting a greater extent inland for the houses. There are also spurs running down to the coast at right angles to the mountains forming valleys, of which there are three principal ones. From this it follows that the shelter is less perfect, there is more wind, and the temperature is lower than in the east bay. "Mentone's capabilities as a health station are not a little augmented by this provision of two varieties, two modifications, of the Riviera climate within a radius of less than a mile; and a knowledge of the points of contrast between these east and west bay climates is necessary in selecting the place of residence for an invalid.

In the side valleys, before mentioned, grow luxuriantly the orange and lemon, interspersed with figs, olives, and many other trees and shrubs of a semitropical nature. The time to see nature in her most luxuriant garb is unfortunately when the "season" is over, in the late spring and early summer. The writer, on a visit in June to this place, found a deserted village so far as visitors were concerned, but nature at her best, resplendent in the beauties of a semitropical vegetation. In the west-bay district are the two great resorts for visitors, the "Promenade du Midi" skirting the sea, and the "Jardin Public." Here from eleven to two o'clock the invalids and their friends take their sun and air bath, fanned by the midday sea breeze which frequently blows. The old town in the east bay is picturesque with its winding and narrow streets. "The Mentonian amphitheatre is virtually a great natural hothouse; the east bay is the warmer half of the hothouse; the eastern portion of the east bay, the district called Les Cures, is the warmest corner of all" (Richards). The population of Mentone is 94,000, largely augmented by the winter visitors. There are abundant and excellent accommodations of varying prices, though as a rule the Riviera is rather expensive. The drainage is very good, and, so far as the writer's experience goes, so is the water supply. All the visitor's and invalid's wants can be well supplied at Mentone; there are good shops, good doctors and dentists, and several English churches. The excursions about Mentone are most attractive and varied, and can be made either by carriage or afoot. "The best walks and drives are those along the coast extending from Cape St. Martin to the Italian frontier." Mentone can be reached from London in twenty-eight hours, and from Paris in nineteen and a half.

The characteristics of the Mentone winter climate are thus summarized by Dr. Bennet, who spent many years there: "Absence of frost, prevalence of northerly winds, moderate dryness of the atmosphere, complete absence of fog, paucity of rainy days, clearness and blueness of sky, general heat and brilliancy of sun, cool night temperature, a bracing coolness of the atmosphere generally, and a mean difference of 12.8° F. only between the day maximum and the night minimum."

The meteorological table, on the following page, from the article on *Mentone* by Dr. Richards in the former edition of the HANDBOOK gives various climatic data.

FIG. 3334.—Mentone; the Southern Promenade.

The average temperature at Mentone, from October to May inclusive, is 55.5° F. In the east bay it is 56.25° F.; in the west bay it is 54.86° F. The absolute minimum temperature at Mentone during ten consecutive winters, according to Dr. Yeo ("Climate and Health Re-

METEOROLOGICAL TABLE OF MONTHLY MEANS FOR MENTONE. (FROM SPARKS' "RIVIERA.")

Authority and Number of Years.	October.	November.	December.	January.	February.	March.	April.	May.
Mean temperature of West Bay, Freeman, 1863–66	62.2	57.2	51.7	49.2	50.3	51.5	58.6	63.1
Mean temperature of West Bay, Andrews, 1873–78	....	54.1	49.68	49.05	48.63	50.71	56.69	
Mean temperature of East Bay, Farina and Castillon, 1861–77	65.3	55.3	50.55	49.9	50.6	53.9	58.7	65.76
Mean Maxima, Andrews, 1873–78	....	61.91	58.01	57.51	57.39	59.38	65.25	
Mean minima, Andrews, 1873–78	....	46.38	41.51	40.63	39.69	42.03	47.97	
Mean daily range, Freeman, 1863–68	10.7	9.9	9.2	10.5	11.4	11.8	12.5	
Barometer, Freeman, 1863–65	29.84	29.91	30.06	30.03	29.86	29.71	30.01	
Relative humidity, Freeman	72.0*	75.0*	72.0*	72.0†	70.0†	74.0†	74.0†	
Rainfall, Freeman and Andrews, 1863–66 and 1873–78	6.37‡	3.73§	3.475§	1.242§	1.45§	3.69§	3.293§	2.37 ‖
Highest fall in each month (corresponding period)	13.52	6.94	7.93	2.17	3.26	6.83	6.8	3.9
Lowest fall in each month (corresponding period)	1.55	1.05	.12	.03	.31	.33	.09	1.68
Rainy days (corresponding period)	8.0	10.1	7.25	5.1	5.66	9.55	9.33	11.0
Rainy days, De Bréa, 1851–60	9.0	9.4	5.9	7.9	5.5	6.1	7.3	9.3
Very fine days, De Bréa, 1851–60	16.1	15.4	19.5	17.3	16.3	17.7	15.3	15.4
Very fine days, Freeman and Stiege, 1863–68, and Sparks, 1875–78	....	15.0	15.6	14.8	15.0	12.7	15.0	
Calm days, Stiege, 1863–68	....	22.0	23.0	19.0	20.0	18.0		
Windy days, Stiege, 1863–68	....	8.0	8.0	12.0	8.0	13.0		

* Two years. † Three years. ‡ Five years. § Eight years. ‖ Four years.

sorts") was 25.5° F. and the absolute maximum 77° F. The mean daily range of temperature was found to be least in December, 9.2°, and greatest in April, 12.5° The average rainfall from October to May inclusive is 25.61 inches; but if October and May are omitted, it is only 17.87 inches for the remaining six months. The corresponding number of rainy days is 63.8, October and May included, and 45.15 excluding these months. January and February have the smallest amount of rainfall and the fewest rainy days. October is the wettest month. "The average number of very fine days for the six winter months, from November to April inclusive, seems to be about 94.5, rather more than fifteen in each month" (Dr. Yeo). The number of fine days for the year —days on which the sun shines without clouds—is 214; the number of days on which the sun shines with clouds is 45, and the number of days on which the sun does not shine, but which are without rain, is 24. The relative humidity for the year is between 70 and 72 per cent., a little higher than that of the other Riviera resorts, caused by the absence of the dry land winds which are shut off by the neighboring elevations. In regard to the winds, the *bête noir* of all the Riviera resorts, Mentone enjoys greater immunity from them than any other spot on this coast, owing to its better protection. The northwest wind, or mistral, is less common than at some other points on the Riviera, and when it occurs it is most felt on the west bay; while the east bay is scarcely touched by it. Although the prevailing winter winds are from the north, such is the protection from the mountains round about Mentone that they are not felt there, and do not touch the Mediterranean until a point is reached several miles out from shore. "Of other winds," says Burney Yeo, "the east wind is felt chiefly along the shore, and shelter from this wind can always be obtained in the walks and drives along the valleys behind the west bay. South, southwest, and southeast winds, all coming across the sea, have free access to Mentone, but these are not, as a rule, cold winds, although they may blow at times with considerable violence. From the north wind it is completely protected." "In October and the early part of November," says Dr. Bennet, quoted by Richards, "southwest winds prevail, bringing the heavy autumnal rains. Then the north winds gain the upper hand, and usually, but with occasional temporary exceptions, reign until the spring months, March and April. At this epoch the southwesterly and southeasterly winds seem to have the ascendancy, giving rise to the gales and rains of March." In conclusion Dr. Richards remarks that there is always wind enough for health, seldom enough to cause discomfort; and that upon the occasions when too strong or too chilly a wind is felt along the shore line, it may be always escaped by the invalid who will take shelter in some one of the torrent valleys opening into the west bay. "For those," says Dr. Yeo, "who especially desire warmth and shelter, and a quite indolent life, with plenty of sunshine, and sun heat, and who like to live close to the sea, there is the mild and sedative climate of the east bay." "For those, on the other hand," he continues, "who find an advantage from a more bracing air, who like to have the sun heat tempered by cooling winds, who cannot feel at ease without 'ample space and room enough' to wander free over hill and valley, or who are irritated by the monotonous beat of the tideless sea against the shore,—for those there is the west bay with hotels and villas, some on the seashore, some a little removed from it, some . . . far removed from the sea and high up on the hillside."

The class of cases for which the climate of Mentone can be recommended comprises those who require a warm, sunny atmosphere, and who do best in mild winter weather; the aged, weak, sickly children, scrofula, laryngeal diseases, chronic bronchitis, gouty and rheumatic affections, anæmia, convalescence from acute disease, and some favorable forms of pulmonary tuberculosis, although in the writer's opinion, as expressed in the article upon Cannes in this HANDBOOK, the climate of the Riviera is not the most favorable one for the arrest or cure of this disease, notwithstanding the conviction of Dr. Bennet uttered twenty-five or thirty years ago, "that there is a greater probability of the disease (consumption) being arrested, of life being prolonged, and even of a cure being eventually effected if the patient can winter in the south than if he remains all winter in the north of Europe." Since this was written, however, the experience at Davos and at the various sanatoria in Germany seems to have conclusively demonstrated that the systematic use of pure cool air in elevated regions produces better results than mere warm moist air at sea-level. In either case, however, as Dr. Bennet himself says, climate is not alone to be relied on, but the patient must be under constant and judicious medical management. When such medical supervision is available, and particularly if it is exercised in a sanatorium, almost any climate which affords pure air and plenty of sunshine may prove beneficial to the patient. It is said, however, that the climate of Mentone is not suited to certain nervous maladies such as epilepsy, neuralgia, and the violent forms of hysteria.

At Usorbio, near Mentone, is a winter sanatorium, opened in October, 1900. It has fifty-three rooms for patients, and tuberculous subjects of various nationalities are treated there. *Edward O. Otis.*

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Hermann Weber: The Treatment of Disease by Climate.

MERAN is situated in the Austrian Tyrol, about forty-five miles south of Innsbruck and twelve miles north of Botzen, in a well-sheltered valley, at an elevation of about 1,100 feet above the level of the sea. It is reached from London, viâ Innsbruck-Botzen, in forty-four hours. The population is 3,000, and the number of visitors is 10,000.

Meran is a health resort of a threefold character, and has three distinct seasons, which, combined, embrace nearly the entire year, with the possible exception of the mid-summer, when the weather is sometimes excessively hot. The three varieties of treatment practised here may with advantage be considered separately.

A Winter Health Resort.—The town of Meran, with the neighboring villages of Obermais, Untermais, and Gratsch, lies in the beautiful Etschthal, well protected from the north, east, and west, and exposed only to the southerly winds. The mean annual temperature is about 54° F. It is colder here in winter than it is in most of the health resorts of Southern Europe, but the place has the advantage of a very equable temperature, and of a very unusual number of clear or cloudless days. Although frost and snow are not unknown, the cold is never intense nor of long continuance, and there is a great deal of warm sunshine. The valley is so well protected from the cold winds that the invalids and other visitors are able to take exercise in the open air nearly every day. The air, in addition to being mild and of an equable temperature, is very dry, and the rainfall is comparatively slight, there being an average of only eleven rainy days during the winter. The following table, arranged rom figures given by Knauthe, in the article on Meran in "Eulenburg's Real-Encyclopädie," shows the average temperature for the fall and winter months. These temperatures are not given as strictly accurate, but they will serve to indicate approximately the winter climate of this resort.

	Morning.	Noon.	Evening.
September	58.3° F.	69.8° F.	64.4 °F.
October	51.8	60.8	57.4
November	37.2	45.7	37.4
December	30	37.2	29
January	29	36	29
February	30	40	34.7
March	39.6	54.3	45.5

Vegetation begins again in February, and the winter, strictly speaking, is limited to the three months of November, December, and January, November being the only one in which the weather is at all apt to be disagreeable.

By reason of the climatic advantages just enumerated, —viz., a rather cool, bracing atmosphere combined with equability of temperature, plenty of warm sunshine, and absence of moisture—Meran is frequented during the winter by numbers of invalids suffering from chronic catarrhal affections, especially those accompanied by profuse mucous expectoration from the respiratory passages. As a further indication it may be mentioned that invalids of this class who seem to derive the greatest benefit from a stay at this resort are those of a scrofulous diathesis, and of a languid or even lazy disposition. Persons suffering from pulmonary phthisis in its early stages are often much benefited by a winter at Meran, but a residence here is said to be contraindicated for those in whom the tuberculous process has advanced to softening and breaking down of the lung tissue, with the formation of cavities. People of an excitable, nervous temperament, who are suffering from insomnia and nervous tension caused by overwork, anxiety, or excesses of any kind, often experience a great amelioration of their condition during a few weeks or months spent in the mild, dry, equable climate of this valley. The winter season extends from the first of November, the end of the grape-cure, to the first of April, the beginning of the whey-cure season.

The Whey Cure.—Whey is made from cows' and goats' milk chiefly. It consists of the serum of the milk remaining after the separation of the fat and casein, and is little more than a watery solution of sugar of milk and of various salts, chiefly chlorides and phosphates of sodium and potassium. It is made by adding rennet to milk warmed to a proper temperature, and precipitating the suspended casein by the addition of a small amount of albumen. The whey used at Meran is prepared at a neighboring village, and brought thence, every morning, in bottles kept in warm water (from 97° to 100° F.) so as to prevent the temperature of the whey from falling below the prescribed degree during its transportal. The whey is dispensed in a large building which resembles the Trinkhalle or pump-room of a German spa. The usual time for drinking the whey is from six to eight o'clock in the morning. A large glass is taken about once in fifteen minutes until from four to seven have been consumed, the drinkers meanwhile walking about slowly. About an hour after the last glass has been drunk, a light breakfast, consisting usually only of coffee and a roll, is taken. No acids nor uncooked food are allowed during the whey treatment, and milk, butter, and cheese are also forbidden. These raw-milk products are stricken from the dietary, because they contain precisely the ingredients of the milk which have been abstracted in the production of the whey, and it is regarded as irrational to give with one hand what has been taken away with the other. The whey is taken pure, or it is mixed ("cut," as it is called) with some mineral water, or the expressed juices of certain herbs are added.

The Herb-juice Cure.—This is a mode of treatment practised at many health resorts on the Continent, especially in various parts of Germany and Austria. The juices of various herbs, usually wild plants growing in the neighborhood, are extracted from the fresh plant by pressure, without the aid of water, and are then drunk by the patient. The juice of one herb alone is taken, or those of several herbs are mixed together and prescribed, according to the supposed indications of the individual case. The following are some of the plants from which the juice is expressed and drunk, with their alleged therapeutic properties: *Achillea millefolium*, milfoil or yarrow—a remedy which has been used in flatulent dyspepsia, and also by the Italian peasants in intermittent fever. *Allium sativum*, garlic; diuretic, diaphoretic, expectorant, and alleged also to be emmenagogue. *Apium petroselinum*, parsley; diuretic and aperient. *Cardamine pratensis*, meadow cress; said to possess antispasmodic properties. *Fumaria officinalis*, called also *Herba melancholifuga*, fumitory; has a popular reputation in the treatment of eczema and various other skin affections. *Glechoma hederacea*, ground ivy; expectorant and tonic. *Leontodon taraxacum*, dandelion; diuretic, aperient, and an hepatic tonic. *Menyanthes trifoliata*, water trefoil; has an intensely bitter taste, is tonic, diuretic, and cathartic. *Tussilago farfara*, coltsfoot; expectorant and demulcent, a popular remedy in coughs. *Veronica beccabunga*, water speedwell; supposed to be alterative and tonic. Many other plants are also used, each locality drawing upon the flora of its own neighborhood.

At Meran the most commonly used herbs are the dandelion, water trefoil, speedwell, and cress. The juices are usually prescribed in conjunction with the whey treatment. The whey is taken in the morning, in the manner described, and in the evening, between five and seven o'clock, from half an ounce to two ounces of herb juice are drunk. At the beginning of a course of whey and herb-juice treatment, the patients are made to rest most of the time, but after a week or so they begin to exercise according to a fixed daily routine, often counting the steps taken, as is the custom in so many establishments of this kind.

Patients suffering from chronic gastritis, certain forms

of dyspepsia, hepatic congestions, anæmia, and chlorosis, are not infrequently greatly benefited by the fine climate, and by the regular mode of living enjoined upon those who submit themselves to the whey cure. Patients with respiratory catarrhs or incipient phthisis, who have passed the winter at Meran, often remain in the spring to take a course of the whey treatment. The season for the whey cure extends from the first of April to the middle of June, although by some it is extended through the summer, until the grape-cure season begins.

The Grape Cure formerly enjoyed a greater reputation as an efficient therapeutical measure than it does at present, but it is nevertheless still employed to a considerable extent. Grape juice contains a varying proportion of grape sugar, vegetable albumen, and a number of organic acids existing alone or in combination with inorganic bases. The immediate effects of the ingestion of a large quantity of grapes are a little lightness of the head and slight dyspeptic symptoms, followed soon by rather active movement of the bowels and increased diuresis. This action on the bowels tends to reduce the blood tension in the internal organs, especially those in close anatomical relation to the intestinal tract.

At Meran the grapes are eaten in the vineyards or in the large building, resembling an ordinary German Trinkhalle, where, earlier in the season, the whey is drunk. The daily dose of grapes is from two to four pounds in the morning, before breakfast, and about one pound after each of the two principal meals. The season extends from the first of September to about the end of October.

The grape cure is recommended in the treatment of habitual constipation, hemorrhoids, passive congestion of the abdominal viscera, some forms of chronic diarrhœa and dysentery, cardiac troubles, gout, chronic bronchitis, and even commencing pulmonary tuberculosis. Those who intend to pass the winter at Meran, because of threatened or beginning lung troubles, are often advised to go there a little before the regular winter season begins, in order to take a course of the grape cure.

In addition to the therapeutic methods of which mention has just been made, Russian baths and mud-baths are much used, and fresh milk or kumyss is employed to a considerable extent throughout the year. There are also electric baths, massage, the Terrain Kur, and the compressed-air treatment by the use of pneumatic air chambers.

Meran is a most attractive place for the ordinary tourist in search of pleasure, as well as for the invalid seeking health. It lies in a beautiful valley, and in the neighborhood many agreeable walks may be taken to points affording a view of picturesque scenery, or to the numerous castles, many of them in ruins, for which this part of the Tyrol is famous. A large dike, erected to protect the town from the destructive inundations which, in former times, not infrequently caused serious damage to property and loss of life, is the favorite promenade for the inhabitants and visitors. The hotels and boarding-houses in Meran are numerous, and are, as a rule, clean and well kept, while the cost of living is not very high. At the casino may be found newspapers from all the leading countries. There are numerous churches, and persons of the Catholic, Protestant, or Hebrew faith will find opportunities to worship according to their own belief; there are, also, services for the accommodation of English-speaking Protestants. There are many competent resident physicians in the place.

[From the first edition of the Handbook—revised by *Edward O. Otis.*]

MERCURIALIS. See *Euphorbiaceæ.*

MERCURY.—I. General Medicinal Properties of Compounds of Mercury.—All mercurials capable of gaining entrance into the circulation are competent for a certain peculiar influence over nutrition, as follows: In small dosage the tendency is, as in the case of iron, to increase the quantity of hæmoglobin present in the blood—an effect trifling in the case of a person in good health, but distinctly marked in an anæmic syphilitic patient. In the syphilitic, furthermore, mercury tends to shorten the course and lessen the severity of the eruptions and inflammations due to the disease. In large dosage, or in too rapidly pushed small dosage, the effects become deleterious. The albumin and fibrin of the blood are lessened in amount, coagulability is impaired, and degeneration and absorption of tissue, and inflammation of certain glands and other structures follow. These phenomena, constituting general mercurial poisoning, may lead to long-continued impairment of health, or even to death. In the medicinal induction of the constitutional mercurial influence, or *mercurialization*, as it is commonly called, it may be necessary, for the gaining of the full therapeutic benefit, to push the dosage until the verge of poisoning be reached, but never further. The symptoms of incipient mercurial poisoning thus become of clinical importance, and are as follows, taking their character from the fact that the salivary glands and buccal structures are peculiarly obnoxious to the poison: *Subjectively*, there are noticed a metallic taste in the mouth, and a little soreness in the sockets of the teeth on bringing the jaws sharply together. *Objectively*, the gums are observed to suffer from a slight inflammation, of which the signs are, first, but very transiently (often escaping notice altogether), an unnaturally white appearance from unduly rapid proliferation of epithelium. This aspect soon gives way to the classical picture of red, swollen, and spongy gums, and along with the development of this condition begin an increased flow of saliva and a little tenderness, perhaps even swelling, of the parotid glands. Simultaneously, there may be a deranged stomach, relaxed bowels, and general mild malaise with a trifle of fever, and unnatural susceptibility to "catching cold." All these symptoms disappear readily and completely on stopping the medication. Beyond them, the effects belong wholly to the category of the poisonous, for the discussion of which see the following article.

An important point of obvious clinical bearing is that in childhood ages—and the younger the more marked—the symptoms of incipient poisoning differ from the picture just given in that the salivary apparatus is comparatively insensible to the mercurial irritation. In other words, *children* are not easily *salivated* in the strict etymological meaning of the word. But while this is literally so, it does not follow, and in point of fact is not true, that children are not proportionately as much *blood-poisoned* by mercury as are adults. Rash over-mercurializing of children, because of the false security drawn from the non-appearance of salivation, may therefore lead to disastrous effects.

The deranging effect of mercury, as thus sketched, upon the human organism, is but a single exemplification of a general tendency which the metal has to poison all living things, animal or vegetable, high or low in the organic scale, alike. Few poisons, indeed, are so universally and so intensely obnoxious to life generally as is mercury. To the low organisms especially, that are associated with the processes of putrefaction and fermentation, mercury is powerfully poisonous, and the soluble mercurial preparations are therefore highly antiseptic.

For discussion of the *absorption* and *elimination* of mercury, see article on *Mercury, Poisoning by.*

As regards *local* effects there is great difference among the individual mercurials. In general the *mercuric* compounds are more or less decidedly irritant, though not astringent; while the *mercurous* compounds and the preparations containing mercury in the metallic state, are either quite bland or only mildly irritant. In the alimentary canal, all mercurials show a decided tendency to relax the bowels, which, with the large doses possible with the milder mercurials, may develop into full purging. In such case the stool are mucous in quality, and are notable for the considerable amount of bile which they contain. By the very virtue of this purgative effect a mercurial purgative dose is itself hurried along the intestines and discharged per anum before time has sufficed

for absorption. The *mild insoluble mercurials* are thus possible of application as simple laxatives or cathartics. The *irritant* mercurials, taken internally, even in small medicinal dosage, have an annoying tendency to irritate the stomach as well as the bowels, and loss of appetite, with epigastric uneasiness and tenderness, and perhaps nausea, often follow so quickly the beginning of a course of a mercuric salt that the medication has to be discontinued or changed. In large doses the *mercuric* compounds are powerful irritant poisons—the more soluble ones, such as corrosive sublimate, even intensely so. Death may follow in the case of poisoning by the latter compound, by sheer irritation, before the mineral has time to work any specific constitutional mercurial effect (see article *Mercury, Poisoning by*).

Therapeutically, mercurials are of manifold application. *Constitutionally*, general mercurialization is wellnigh universally applied in the treatment of syphilis, and in older times, more than now, was used in the treatment of other cachexiæ also. *Locally*, in the alimentary canal mercurials are used to check vomiting, to purge and to correct digestive disorders, even of incongruous kinds. *Externally*, parasites, vegetable and animal, can be destroyed, ulcers and sores coaxed to healing, and eruptions (especially if syphilitic) to disappearance, and wounds successfully treated on so-called "antiseptic" or "aseptic" principles.

II. The Preparations of Mercury Used in Medicine.—The compounds of mercury affording mercurial medicines, official in the United States Pharmacopœia, are as follows:

1. *Mercury Uncombined.* Metallic mercury, in bulk; metallic mercury, in fine subdivision, by trituration with an excipient.

2. *Mercurous Compounds.* Chloride (*Subchloride, Protochloride, Mild Chloride, Calomel*); Iodide (*Protiodide, Yellow Iodide, Green Iodide*). Also, extemporaneously formed by a certain prescription of mercurous chloride, mercurous oxide (*Black Oxide, Protoxide, Suboxide*).

3. *Mercuric Compounds,* Oxide, in crystalline scales (*Binoxide, Peroxide, Red Oxide, Red Precipitate*); Oxide, in amorphous powder (*Binoxide, Peroxide, Yellow Oxide*); Chloride (*Bichloride, Perchloride, Corrosive Chloride, Corrosive Sublimate, Sublimate*); Iodide (*Biniodide, Periodide, Red Iodide*); Cyanide (*Bicyanide*); Basic Sulphate (*Subsulphate, Yellow Sulphate, Turpeth Mineral*); Nitrate; Oleate; Ammonio-chloride (*Ammoniated Mercury, White Precipitate*).

Mercury Uncombined.—Mercury in bulk is ordinarily not affected by any of the fluids of the skin or digestive tract, and so is without medicinal effect. Its only therapeusis is to overcome mechanically an intestinal obstruction, which it has in some cases succeeded in doing. For such purpose, from a few ounces to a pound or two of the metal is to be swallowed at a draught. Rarely, constitutional effects have followed such administration, but generally the metal passes down the alimentary canal unchanged.

Mercury in fine subdivision—"extinguished"—by thorough trituration with some excipient, acts, generally, like the mercurous compounds, producing specific mercurial effects, local and constitutional. Undoubtedly, therefore, the metal in these trituration preparations is changed into some soluble mercurial salt by the juices of the part to which it is applied, but the nature of the reaction is very obscure. The trituration preparations of the United States Pharmacopœia are as follows:

Massa Hydrargyri: Mass of Mercury, "Blue Mass," "Blue Pill." Metallic mercury is triturated with honey of rose and glycerin until "extinguished"; liquorice and marshmallow roots in due proportion are then added, and the whole is again subjected to trituration "until globules of mercury are no longer visible under a lens magnifying at least ten diameters" (U. S. P.). The product is a dull indigo-colored pill mass, containing at least thirty-three per cent. of mercury. No weight of individual pills, be it observed, is directed by the United States Pharmacopœia. Blue mass is used only for internal medication, and behaves like calomel in milder degree. In single large dose it is mildly laxative, producing bilious stools; in small repeated dose it affects the system at large, mercurializing promptly and efficiently, but yet with a tendency to relax the bowels. Therapeutically, blue mass is applied to correct disorders of the alimentary apparatus, or to mercurialize generally, in treatment of syphilis. For the former purpose a single dose is given, generally at night, ranging from 0.30 to 1 or even 1.50 gm. (from gr. v.–xv. or xx.). If the smaller of these quantities be prescribed, a brisk purge is commonly ordered to be taken the following morning on rising, to insure the discharge of the mercurial from the bowel; but if the larger doses be given, the blue mass may "work itself off" by its laxative power in such quantities. To *mercurialize* by means of blue mass, from 0.30 to 0.60 gm. (gr. v.–x.) of the medicine should be a day's allowance, broken up into at least three doses, equidistant in time; the administration being continued either until the therapeutic point is gained, or until the forerunning symptoms of salivation warn to stop. Should the bowels become unduly relaxed, 0.01 gm. (gr. $\frac{1}{6}$) of opium should be added to each pill. Blue mass is prescribed in pill form, three grains to each pill, ordinarily.

Hydrargyrum cum Cretâ, Mercury with Chalk, "Gray Powder." Mercury is shaken with clarified honey, in a strong bottle, until globules of mercury are no longer visible under a magnifying powder of four diameters. The product is then triturated with a thick cream of prepared chalk rubbed with water, and the whole then dried and reduced to a uniform powder. The resulting preparation is a smooth, light gray powder containing thirty-eight per cent. of mercury. Being practically all metallic mercury and chalk, it is insoluble in water. Mercury with chalk is naturally very mild, yet in some samples causes irritation, an effect that may possibly be due to contamination with arsenic or antimony, but which probably is more commonly caused by the slow conversion of a portion of the mercury into mercuric oxide. This contamination with mercuric oxide may be detected by treating a portion of powder with dilute hydrochloric acid, and adding stannous chloride to the resulting clear solution. If mercuric oxide be present a black precipitate falls. And for safety's sake, if a sample of mercury with chalk be kept for any time, this test should occasionally be applied.

The action of mercury with chalk is substantially that of blue mass, but weaker, and with less tendency to relax the bowels. The influence of chalk, indeed, is to constipate, and so it comes about that in the average dose little laxative effect is produced by gray powder. Constitutionally, despite its mildness, the preparation is competent to mercurialize, and for the very reason of its mildness is particularly serviceable when the object is to maintain a gentle mercurial influence steadily for a considerable time, as in certain methods of treating syphilis. For such purpose 2 or 3 cgm. (from gr. $\frac{1}{3}$ to $\frac{1}{2}$) should be prescribed three times daily. If rapid and sharp mercurialization be called for, a more active preparation must be selected. But the commonest application of mercury with chalk is for the correction of disorders of the alimentary apparatus, particularly those, so common in children, where the prominent symptoms are malassimilation of the food with fermentation and diarrhœa, or where clay-colored stools occur, whether with diarrhœa or with constipation. In such affections gray powder may be given, best in quite small but frequently repeated dosage, such as a centigram or two (one-sixth to one-third of a grain) every hour for a day, unless improvement be sooner effected. Such medication should not be persisted in beyond a day or so, else mercurialization will ensue. The medicine can be taken clear, as a powder, since it has little taste, or it may be put into any convenient mixture. The pill form is bad for gray powder, since by too much pressure the globules of mercury in the preparation are apt to run together.

Unguentum Hydrargyri, Mercurial Ointment, "Blue

Ointment." Mercury is triturated to extinguishment with four per cent. of the pharmacopœial oleate of mercury, and the triturate then further triturated with nearly its own weight of a mixture of lard and suet in nearly equal proportions, previously melted together and partially cooled. The resulting preparation should show no globules of mercury under a magnifying power of ten diameters.

The process of trituration is very tedious, and the preparation is generally made by machinery on the large scale and bought by the dispensing pharmacist from the wholesale manufacturer. In the making, the commonest fraud is in the matter of the quantity of mercury present, which in commercial samples, is often found to be greatly below the standard.

Mercurial ointment is of analogous color to mercurial pill mass—a dull indigo slowly darkening with time. By far the greater quantity of the mercury contained in this ointment is in simple mechanical subdivision, but yet a certain small proportion has probably become converted into mercurous oxide, and this in turn has reacted upon the lard, or upon certain products of the decomposition thereof. And to these undetermined secondary compounds some are disposed to ascribe the medicinal activity of the ointment.

Mercurial ointment is the mildest of the official ointments containing mercury. It does not irritate the sound skin unless rubbed in, and that, too, repeatedly at the same spot. Medicinally, it fulfils, mildly, the local therapeutics of mercurials, and also—its most valuable property—when applied by inunction, gains entrance in some way to the general circulation and mercurializes the whole system rapidly, thoroughly, and, because of its avenue of access, with a minimum of disturbance of stomach and bowels. Just how and in what chemical combination the mercury enters the blood in such case has been a subject of much speculation and theory, but the matter is still unsettled and is one of no practical bearing. The uses of mercurial ointment are for the purely local purposes of mercurial applications generally, to destroy parasites, or to set up healthy action in sores, eruptions, or glandular indurations not far below the skin surface, and also to mercurialize in syphilis, especially when speedy and thorough action is wanted. For simply local effects, the ointment is applied in the common way, but to mercurialize the system at large a special procedure is requisite, of which the point is that the preparation is to be rubbed thoroughly into the skin, until absorption of the mercury takes place through the tissue of the same. To insure speedy absorption, the application is made where the skin is thin and without much underlying fat, as is the case on the inner aspect of the upper arm or the thigh and on the sides of the trunk. At least four, and, better, six sites should be used in succession, in order to save the irritation that follows too frequent inunction upon one spot. The proceeding is as follows: At night the selected site is well cleansed with soap and water, and dried. Then, preferably before a fire, weather and circumstances favoring, the quantity of from 2 to 4 gm. (ʒ ss.–i.), according to the urgency of the case, is rubbed in until the ointment has apparently disappeared. The part is then bound up in flannel, and is not washed until the following morning. This manœuvre is repeated nightly, or, possibly, even twice a day, until either the desired therapeutic effect is obtained, or until beginning of soreness of the gums enforces discontinuance. One or the other result is commonly attained inside of a week. If the patient require to have the inunction done by somebody else, the hand of the rubber must be protected by a glove of caoutchouc or other device to guard against self-mercurialization. In the case of infants a piece of the ointment of the size of a pea may simply be smeared upon the skin of the axilla, or of the popliteal space. The ceaseless natural motions of the child then suffice for the rubbing.

Emplastrum Hydrargyri, Mercurial Plaster. Metallic mercury is triturated to extinguishment with a small quantity of the pharmacopœial oleate of mercury and the product then mixed thoroughly with melted lead plaster. The resulting plaster contains thirty per cent. of mercury, and possesses to a slight degree the local specific virtue of mercurials, in addition to the usual properties of plasters.

Metallic mercury is also an ingredient of the plaster entitled *Emplastrum Ammoniaci cum Hydrargyro*, Ammoniac Plaster with Mercury; for whose composition see Ammoniac.

Mercurous Compounds.—The series of mercurous salts which come next for discussion are all insoluble in water and, accordingly, are locally bland. Internally, in single full dose, they are purgative; in small repeated dose they mercurialize rapidly, with especial tendency to produce the specific features of salivation, in the restricted sense of the word.

Mercurous Chloride, Hg_2Cl_2. Mercurous Chloride is official in the United States Pharmacopœia under the title *Hydrargyri Chloridum Mite*, Mild Mercurous Chloride. It is also known, in the terms of a former chemical nomenclature, as *subchloride* or *protochloride* of mercury, and, more commonly yet, in the vernacular, as *calomel*. Calomel is bought by the dispensing pharmacist from the large-scale manufacturer, its preparation—to be done well—requiring special apparatus. The principle of the process ordinarily followed is to subject to sublimation a mixture of mercury, mercuric sulphate, and sodium chloride. By a preliminary trituration of the mercury and mercuric sulphate mercurous sulphate forms, and, upon heating, this mercurous sulphate exchanges acid radicals with the sodium chloride, with the forming of mercurous chloride and sodium sulphate. The calomel sublimes, and, according to different methods of preparing, condenses either in a crystalline cake or as an impalpable fine powder. If obtained in cake, this requires pulverization in order to submit the calomel to a thorough washing with water, for the removal of traces of mercuric chloride that form along with the calomel. If condensed as powder, it is through the agency of steam (Jewell's or Howard's process), which, as it determines condensation, also very thoroughly accomplishes the necessary washing. Calomel made by the latter process is the most esteemed, and can be distinguished by its snowy whiteness, as compared with the yellowish tint of calomel obtained by the other method.

Calomel is a white, impalpable powder, permanent in the air, odorless and tasteless, and insoluble in water, alcohol, or ether. When strongly heated, it is wholly volatilized, without melting. The most dangerous impurity to which calomel is liable is corrosive sublimate (mercuric chloride), for which the test is to wash the calomel with warm distilled water, and then add to the washings some water of ammonia. If any corrosive sublimate have been dissolved by the washing, a white precipitate (ammonio-chloride) will now fall. Also, there may be contamination with this same ammonio-chloride. To detect this, shake the calomel with acetic acid, filter, and treat the filtrate with hydrogen sulphide, and with solution of silver nitrate. Coloration by the one and the forming of a white precipitate with the other indicate the presence of the ammonio-chloride. Other likely impurities are not dangerous.

The reactions of calomel that have a bearing, real or supposititious, upon its medicinal employment, are first, that free bases decompose the compound with the formation of mercurous oxide, and secondly, that ammonium chloride, and to lesser degree potassium and sodium chloride, in sufficient concentration and at a proper elevation of temperature, tend gradually to convert the mercurous into the mercuric chloride—to change, that is, calomel into corrosive sublimate. Great stress has been laid upon the latter reaction. It has been made to do duty in accounting for all the medicinal activity of calomel, the same being ascribed to the corrosive sublimate into which the calomel is assumed to be changed by the alkaline chlorides present in the contents of stomach or bowels; and for fear of undue rapidity and completeness of such conversion, the taking of common salt during a course

of calomel medication has often been proscribed. On the other hand, it is asserted that the degree of concentration of the alkaline chlorides commonly occurring in the alimentary canal, and the temperature therein, are inadequate to any but a trivial production of the reaction in question. Pending the definite settlement of the question, it is just as well to avoid the joint taking, in any marked quantity, of calomel and ammonium chloride, or even of calomel and either potassium or sodium chloride. Other substances alleged to have the power of converting calomel into corrosive sublimate, are *hydrocyanic acid, citric acid,* and *sugars.* Of these substances the first never needs to be prescribed with calomel, and the averred potency of the other two is far from established.

Locally the action of calomel is absolutely bland, so long as the salt preserves its integrity, but, after swallowing, effects, local or constitutional according to circumstances of administration, declare themselves—which effects, because of the great insolubility of calomel, must be ascribed to some as yet undetermined compound into which calomel is changed in its course along the alimentary canal. The effects differ profoundly, according to whether the medicine is taken in single full dose, or in small repeated doses continued for some days. In the former case, with or without nausea, according to size of dose and sensitiveness of the stomach, and with or without griping, as the case may be, there follows, in about eight hours or so, a call to stool, and mucous passages, brown, yellow, or even green in color, result—green stools being particularly common in the case of children. Such purging, if free, commonly constitutes the whole outcome of the dose; but if not free, constitutional symptoms, showing absorption of the mineral, may follow. The marked coloring of calomel stools has for years been held to be due to an unusual proportion of bile therein contained, and though this has been denied, yet some chemical analyses, as well as many clinical considerations, make it strongly probable that the venerable assumption is correct. In explanation of the considerable charge of bile in calomel evacuations, many theories have been propounded. The oldest is that excess of bile *excreted* must mean excess *secreted,* and therefore it must be taken for granted that calomel in purgative dose in some way stimulates the liver to increased secretion of bile. But against this theory is arrayed an observation that on dosing with calomel animals upon whom a biliary fistula had been established, there was no increase in the amount of bile discharged through the fistula. In rebuttal, however, it is pointed out that the very fact of the establishment of a biliary fistula so changes the ordinary condition of things *in re* liver, bile, and bile's normal intestinal career, that the experiments go for nothing. Apart from this controversy, another theory of the biliary stools following a calomel purge, is that they result as a natural consequence of an assumed action of calomel in rushing down, as it were, the contents of the duodenum, and so preventing that reabsorption of a considerable portion of the bile present in the intestinal contents which is claimed to be a normal occurrence. The latter theory certainly accounts more readily than the former for the well-known corrective effects of calomel purging in so-called biliousness; but both theories are theories yet, and neither is essential to the intelligent clinical use of calomel in the condition in question. Another theory of calomel stools accepts the fistula experimentation as proving that there is no increased flow of bile, and accounts for the bile coloration by assuming that the mercurial prevents the normal development of the microbes that ordinarily determine decomposition of the bile pigment in the intestine.

In small repeated dose calomel mercurializes speedily, but in so doing is especially prone to salivate, and also, even in small dosage, to relax the bowels.

Calomel may quell vomiting, and has the advantage for such purpose that, once swallowed in the condition of powder, it is difficult to dislodge, and so may continue its action despite an occurrence of vomiting shortly after the taking. Calomel may, and commonly does, dissipate readily the symptoms of that digestive disorder called, rather vaguely, "biliousness," particularly when constipation is associated with clay-colored stools. It may also prove an efficient anthelmintic. Locally, calomel is among the standard remedies for the relief of itching.

The *therapeutics* of calomel consist in the above-described applications. As a purge, the dose for an adult is from 0.30 to 1 gm. (from about gr. v.-xv.), given at night, and followed in the morning, if purging do not sooner occur, by some brisk cathartic, such as a dose of salts. Very often, instead of being given alone, calomel is associated with some other purgative such as jalap, in which case its dose must be reduced proportionally. As a corrective in bowel disorders not requiring purging, calomel may be given in centigram doses (one-sixth of a grain), or less, hourly throughout a single day; yet it may be noted that sometimes this method of dosage results in free purging—as free as if a full cathartic dose had been taken. For anthelmintic purposes, full purgative doses are to be given. To mercurialize, from 0.10 to 0.20 gm. (about gr. iij.) should be prescribed to be consumed daily, divided into at least four doses, and the laxative tendency neutralized by a trifle of opium with each dose. Careful watch should be kept for possible salivation, and the medication discontinued, or the dose reduced, at the first signs of soreness of the gums. Calomel may be administered in powder or pill. Externally, for the relief of itching, calomel is best prescribed in extemporaneous ointment, of ten-per-cent. strength.

A special application of calomel is to mercurialize by the process of *fumigation,* so called. This process is based on the fact that calomel sublimes without change, and that when so sublimed and allowed to condense on the naked moist skin, in some way it rapidly gains access to the general circulation, and so mercurializes with great promptness and certainty. At the same time, because of the avenue of introduction, the digestive organs are not deranged. Under circumstances, therefore, where there is a call for both a prompt and powerful mercurial impression, as in some sudden and severe syphilitic inflammation, the method by fumigation is a thoroughly reliable one. The objections to the method are its troublesomeness, and the exposure of the patient to detection of his malady—objections which, while often annoying, should not condemn the use of the method if the necessity be serious. The process is as follows: By any convenient arrangement—as by laying upon a bit of sheet metal properly supported—the quantity of from 2 to 4 gm. (from gr. xxx.-ʒ i.) of calomel is exposed to the heat of an alcohol lamp, while at the same time a small vessel of water, such as the tin cup of a nursery lamp, is set to boil alongside. These contrivances are arranged under a chair, and upon this chair the patient is seated, naked, and covered, all but the head, by a blanket reaching to the ground. The blanket is to be clasped tightly about the neck to prevent the mercurial fumes from rising about the face, in which case they might be inhaled. By this arrangement a small confined chamber is made, within which all the patient's body, excepting the head, is exposed to the combined action of steam and subliming calomel. Free perspiration is soon induced, and in the moist, relaxed condition of the skin thus brought about, the calomel, condensing upon the surface, finds easy access to the circulation. The sitting lasts from ten to twenty minutes, or until all the calomel has disappeared from the metal plate, and then the patient, donning his night-dress without washing, gets into a warm bed for the night. In the morning a bath may be taken. Such fumigations may be made every other day, or, in urgent cases, daily, until the gums begin to show signs of soreness.

Calomel is an ingredient of the pharmacopœial *compound cathartic pills* (see *Colocynth*), and *compound pills of antimony* (see *Antimony*).

Mercurous Iodide, Hg_2I_2. Mercurous iodide, the *subiodide* or *protoiodide* of the old chemistry, is official in the United States Pharmacopœia under the title *Hydrargyri Iodidum Flavum,* Yellow Iodide of Mercury. The salt

is formed by double decomposition, by adding a solution, in water, of potassium iodide to one of mercurous nitrate. Prepared in this way, mercurous iodide appears as a bright yellow powder. It is without odor or taste; is nearly insoluble in water and wholly so in alcohol or ether. It was formerly prepared by direct union of its elements, and then was of a greenish-yellow color and was known as the "green" iodide. Mercurous iodide is slowly decomposed, by light, into metallic mercury and mercuric iodide, and accordingly should be kept in dark amber-colored vials, and away from light.

The action of mercurous iodide is closely similar to that of calomel, and in the doses of it possible in medicine, the iodine it contains is in too small proportion to exert any appreciable degree of its peculiar influence. Mercurous iodide, therefore, like most of the iodides of the heavy metals, is practically but a representative of the medicinal virtues of the metal. Mercurous iodide is used exclusively as a means of mercurializing by the mouth, and is a favorite preparation with many practitioners in the mercurial treatment of syphilis. The quantity of from 0.06 to 0.20 gm. is to be given daily, in divided doses, with due watch kept on the gums. The medicine is most conveniently given in pill, and the important incompatibility must be remembered that potassium iodide decomposes this salt, producing metallic mercury, and the far more potent *mercuric* iodide.

Mercuric Compounds.—Mercuric Oxide, HgO. Mercuric oxide is obtainable in two ways, namely, by decomposing a nitrate of mercury by strong heat, or by precipitating a solution of mercuric chloride by solution of soda. The respective products of these two processes, though identical chemically, differ in their physical features, and both are official in the United States Pharmacopœia under distinctive names, as follows:

Hydrargyri Oxidum Rubrum, Red Mercuric Oxide, "Red Precipitate." This is the oxide made by the former of the processes described above. The preparation is nearly pure oxide, but with a trace of undecomposed nitrate still present. It appears as a heavy crystalline powder of a brilliant, orange-red color, which becomes more yellowish the finer the powder is divided. It is permanent in the air, odorless and tasteless, insoluble in water or alcohol, but wholly soluble in nitric or hydrochloric acid. By heating, it is decomposed into oxygen and metallic mercury, and finally volatilizes without residue.

Hydrargyri Oxidum Flavum, Yellow Mercuric Oxide. The oxide obtained by precipitation as described above. This form of mercuric oxide is a fine, amorphous powder, of a light orange-yellow color, darkening on exposure to light. Its solubilities are the same as in the case of the red oxide. On heating, it first turns red and then behaves the same as the red oxide.

Both varieties of mercuric oxide should be kept in well-stoppered bottles, away from exposure to light.

Mercuric oxide, despite its insolubility, is, like all the mercuric compounds, decidedly irritant, enough so to produce dangerous irritant poisoning if swallowed in overdose. Yet, compared with the other mercuric compounds used in medicine, it is less harsh than the majority. Of the two forms of this oxide, the red is the more irritating because of the mechanical action of the sharp-edged crystalline grains of which it is composed.

Mercuric oxide is used exclusively as a local medicine, to obtain the specific mercurial irritant influence in affections of the skin or of exposed mucous membranes. It is most commonly employed in one or other of the two official ointments: *Unguentum Hydrargyri Oxidi Rubri*, Ointment of Red Mercuric Oxide, and *Unguentum Hydrargyri Oxidi Flavi*, Ointment of Yellow Mercuric Oxide. Both ointments are of similar composition—ten per cent. of the mercurial thoroughly incorporated with the pharmacopœial preparation called simply "ointment." In the case of the ointment of the red oxide, the mercurial is first made into a smooth mixture with a little castor oil. The yellow oxide is also much used in the form of lotion, consisting of the compound suspended in water. This unofficial lotion is commonly called *yellow wash*, and is obtained by mixing together 2 gm. (gr. xxx.) of mercuric chloride and 500 gm. (one pint) of lime water. As in the case of the so-called *black wash* made from calomel, the mercurial chloride is decomposed by the lime and the oxide precipitated. Yellow wash is more irritant than black wash.

Mercuric Chloride, $HgCl_2$. Mercuric chloride, formerly known as *bichloride* or *perchloride* of mercury, is official in the United States Pharmacopœia under the title *Hydrargyri Chloridum Corrosivum*, Corrosive Mercuric Chloride, and is universally known by the familiar name *corrosive sublimate*, or simply *sublimate*. The salt is made on the large scale by subliming a mixture of mercuric sulphate and sodium chloride, and is bought by the pharmacist from the manufacturer. Mercuric chloride is a colorless salt, permanent in the air, and occurring in rhombic crystals or crystalline masses. It is odorless, but has an acrid and persistent metallic taste. It dissolves in 16 parts of water at ordinary temperatures and in 2 parts of boiling water; in 3 parts of cold alcohol and in 1.2 parts of boiling alcohol; in 4 parts of ether and in about 14 parts of glycerin. On heating, it fuses, first, to a colorless liquid and finally volatilizes in dense, white fumes and leaves no residue. The most important contamination of corrosive sublimate is by arsenic, a test for which is the following, quoted from the United States Pharmacopœia of 1880: "If 1 gm. of the salt be dissolved in boiling water, then mixed with 5 c.c. of strong solution of soda (sp. gr. about 1.260) in a long test tube, and about 0.5 gm. of fine aluminum wire, cut into small pieces, be added (a loose plug of cotton being pushed a short distance down the tube), the generated gas should not impart any tint to paper wet with test solution of nitrate of silver,* and kept over the mouth of the test tube for half an hour (absence of arsenic)." Calomel may be another adulteration, easily detected by its non-solubility in water or alcohol; and all other likely contaminating substances will reveal themselves by non-volatility on subjecting the suspected sample of mercuric chloride to sublimation. Corrosive sublimate should be kept in well-stoppered bottles.

The reactions of corrosive sublimate that are important to the prescriber are as follows: The salt forms double salts with ammonium and with sodium chlorides, which double salts are of the same physiological potency as the simple sublimate, but, differing from the simple salt, dissolve very freely indeed in water. Practically, therefore, any desired concentration of aqueous solution of corrosive sublimate can be effected by simply adding sal ammoniac or common salt to such aqueous mixture. Next, corrosive sublimate in aqueous solution *decomposes* by the following agencies: Simple keeping under exposure to light, whereupon calomel and hydrochloric acid separate out; or the addition to the solution of any of the following substances, viz., alkalies or their carbonates, the alkaline earths, soap, tartar emetic, silver nitrate, lead acetates, potassic or sodic sulphides, sulphydrates, soluble iodides, and many animal and vegetable substances. Mercuric chloride, thus, has a wide range of incompatibility.

In its action, mercuric chloride is intensely inimical to life of all varieties and grades, and so operates as a powerful antiseptic. Tissues immersed in a sublimate solution become tough and shrunken, whitish in color, and proof against putrefaction. On the living human system the salt combines the properties of an active mercurial with those of an intense irritant. In concentrated application it is even caustic, but it is not astringent. Taken internally in small, repeated dosage, corrosive sublimate mercurializes, and with a minimum of salivation. But it is very prone to disorder the stomach, producing epigastric uneasiness and soreness, with loss of appetite and even nausea. In comparatively small overdose, the salt is a dangerous poison, and is one of the things most commonly used for poisoning purposes. (For Toxicology, see next article.)

* Five-per-cent. solution in distilled water.

Medicinally, corrosive sublimate is used both externally and internally. Externally, it is applied most commonly in solution, for the destruction of parasites, or for the specific influence of mercury, when a sharp impression is wanted upon skin eruptions, or, again, as an antiseptic in the treatment of wounds. Sublimate lotions may be aqueous or alcoholic, but should not exceed the strength of one-half of one per cent. of the mercurial in solution, lest undue irritation, or even, in extensive application, absorption and poisoning result. As an antiseptic, mercuric chloride is unrivalled in power, experimental research[1] showing that 1 part in 20,000 is the germicidal peer of 1 part in 833 of the next most potent agent. This potency makes the salt available for efficient antisepsis in the treatment of wounds, in solutions of non-irritant and non-poisonous strength. A solution of one-tenth per cent. is used for the wetting of sponges, compresses, and absorbent dressings, a strength of one-quarter per cent. for the gauze, and a strength of one per cent. for silk sutures or catgut. Internally, frequently repeated minute doses of corrosive sublimate, such as 0.001 gm. (about gr. $\frac{1}{64}$) are often of happiest effect in bowel derangements with fermentation of the food. Such small doses are commonly given in simple aqueous solution. To mercurialize, the average dose is 0.004 gm. (gr. $\frac{1}{16}$) three times a day, in solution or in pill with crumb of bread—the pill mass to be made up with particularly thorough trituration. Mercurialization thus induced is not very speedy, and, since the drug is too poisonous ever to be pushed, it is not an eligible mercurial in cases calling for haste. And under any circumstances, the tendency to irritate the stomach is so great that, for constitutional mercurializing, corrosive sublimate is distinctly not desirable. The salt has also been given by hypodermatic injection for treatment of syphilis, about 0.005 gm. (gr. $\frac{1}{12}$) being injected every other day in aqueous solution. But the procedure is objectionable because severely painful.

Mercuric Iodide, HgI_2. Mercuric iodide—"biniodide," "periodide"—is official in the United States Pharmacopœia under the title *Hydrargyri Iodidum Rubrum*, Red Mercuric Iodide. The salt forms by double decomposition on mixing, in solution, mercuric chloride and potassium iodide, and falls as a scarlet precipitate. Collected and dried, it appears as an amorphous powder, permanent in the air; of a bright scarlet color; odorless, tasteless, and insoluble in water. It dissolves in 130 parts of cold alcohol and in 15 parts of boiling alcohol; also in solution of potassium iodide or of mercuric chloride. On heating it turns yellow, then fuses, and finally volatilizes without residue. It should be kept in well-stoppered bottles, away from light. Mercuric iodide may be contaminated by a little undecomposed mercuric chloride or potassium iodide, whose presence can be detected by washing the sample with water, filtering, and testing the filtrate with a five-per-cent. aqueous solution of silver nitrate. Any soluble iodide or chloride will then precipitate the silver. The most important reaction of mercuric iodide is that it forms double salts with the iodides of the alkalies, which salts dissolve freely in water, yielding colorless solutions. This reaction will take place in the official process for making mercuric iodide, if the potassium iodide be taken in excess, the scarlet precipitate that falls on adding the solution of mercuric chloride instantly redissolving on slight agitation, giving, in colorless solution, the potassium double salt. This same potassio-mercuric iodide, under the name of *iodohydrargyrate of potassium*, has been used in medicine, with the claim for it of remarkable powers, but its effects are substantially those of the simple mercuric iodide—just as a solution of the salt itself is substantially but a solution of mercuric iodide in excess of potassium iodide. The physiological properties of mercuric iodide are practically identical with those of the chloride—locally irritant even to corrosiveness, constitutionally mercurializing in the manner just detailed under mercuric chloride. The salt is not much used, yet some practitioners are partial to it for the purposes of a constitutional mercurial, the administration being in doses and with observances identical with those employed in the giving of mercuric chloride. The iodide may be given in pill, or in solution of potassium iodide. If wanted in the latter way, it may be obtained by prescribing an equivalent quantity of mercuric *chloride* to be added to a solution of *potassium iodide*. By reaction red iodide then forms and remains in solution as double salt, in the manner set forth above.

Mercuric iodide is an ingredient of the official preparation entitled *Liquor Arsenii et Hydrargyri Iodidi*, for whose discussion see under Arsenic.

Mercuric Cyanide, $Hg(CN)_2$. The salt is official in the United States Pharmacopœia under the title, *Hydrargyri Cyanidum*, Mercuric Cyanide. This salt is in the form of colorless prismatic crystals, turning dark on exposure to light. It is odorless, but has a bitter, metallic taste. It dissolves in 12.8 parts of cold water and in 3 parts of boiling water; in 15 parts of cold alcohol and in 6 parts of boiling alcohol. It is sparingly soluble, only, in ether. It should be kept in well-stoppered, dark amber-colored bottles. The important chemical facts concerning mercuric cyanide are, that it is decomposed in aqueous solution by hydrochloric acid with evolution of hydrocyanic acid; but that, on the other hand, unlike many other mercurials, it is not precipitated by alkalies or organic matters. In action, this salt is highly irritant and intensely poisonous, uniting to the usual virulence of mercuric salts the poisonousness of the soluble cyanides. Its sole medicinal use has been to mercurialize, as in syphilis, by giving by the mouth, for which purpose mercuric cyanide has been a favorite with some practitioners, under the claim that it mercurializes after the non-salivating type of corrosive sublimate, but with less tendency to irritate stomach and bowels than in the case of the latter compound. But, with the majority of physicians, the extreme poisonousness of the cyanide has very naturally been a bar to its common employment. The dose is the same as with corrosive sublimate.

Basic Mercuric Sulphate, $Hg(HgO)_2SO_4$. This sulphate, commonly called *turpeth mineral*, is official in the United States Pharmacopœia under the title *Hydrargyri Subsulphas Flavus*, Yellow Mercuric Subsulphate. To make this salt, normal mercuric sulphate, formed by direct action of sulphuric acid upon mercury, is subjected to the action of boiling distilled water in abundance. By this means the salt is decomposed into an acid sulphate which dissolves in the water, and a basic salt which falls as an insoluble, lemon-yellow precipitate. The latter is then collected, washed, and dried. The powder thus obtained is permanent in the air and is without odor or taste. It is insoluble in water or alcohol, but dissolves in nitric or hydrochloric acid. It should be kept in well-stoppered bottles, away from light. Probably because of its solubility in hydrochloric acid, this salt is promptly active when swallowed, with the feature that its irritation speedily excites reflex vomiting—a vomiting that pretty thoroughly evacuates the stomach, with but trifling nausea and depression. In such vomiting the mercurial is itself discharged, and no further effects ensue; but if for any reason vomiting does not come on, then irritant mercurial poisoning results, whose severity depends jointly on the quantity of the mineral swallowed and the degree of acidity of the gastric contents. Turpeth mineral is almost exclusively used as an emetic, and is particularly employed in the emetic treatment of croup, where the non-depressing character of the vomiting is held as a recommendation. But the poisonousness of the salt must be remembered. The average quantity required to vomit a child is from 0.12 to 0.20 gm. (gr. ij.–iij.). The medicine may be given in powder.

Mercuric Nitrate, $Hg(NO_3)_2$. Mercuric nitrate is used medicinally only in the two following pharmaceutical preparations:

Liquor Hydrargyri Nitratis, Solution of Mercuric Nitrate "Acid Nitrate of Mercury." Mercuric oxide is dissolved in excess of dilute nitric acid, whence results a dense, clear, nearly colorless, strongly acid liquid, of specific gravity 2.100, and containing in solution "about

60 per cent. of mercuric nitrate together with about 11 per cent. of free nitric acid" (U. S. P.). This liquid is highly corrosive, and is used solely as a searching caustic. It is applied to the part in full strength, and should be used only when a rather spreading action is allowable or desirable.

Unguentum Hydrargyri Nitratis, Ointment of Mercuric Nitrate, Citrine Ointment. Lard oil, heated, is dosed with nitric acid, whereby the olein of the oil is changed to elaidin. To this mixture, when nearly cold, is added a solution of mercuric nitrate obtained by dissolving metallic mercury in nitric acid. The product is a yellow ointment, decidedly irritant, and exerting powerfully the local specific medicinal powers of the mercuric compounds. Citrine ointment is thus available to destroy parasites, or to excite a healing action in indolent ulcers or eruptions. Unless a strong effect is needed, the ointment should be diluted with lard in equal parts.

Mercuric Oleate. Formula of normal oleate, $Hg(C_{18}H_{33}O_2)_2$. The only condition in which an oleate of mercury is official in the United States Pharmacopœia is in the preparation entitled *Oleatum Hydrargyri*, Oleate of Mercury. The quantity of ten per cent. of dried yellow mercuric oxide is dissolved in oleic acid. If made with oleic acid of standard quality the product is a transparent, yellowish, oily liquid; but if an impure commercial acid be the basis, it is a soft semisolid. The preparation is liable to undergo slow change with deposition of metallic mercury, but the better the quality of the oleic acid used in the making, the slower the decomposition. The "oleate" represents ten per cent. of a mercuric oleate in solution in excess of oleic acid. Its properties are those of a moderately irritant mercuric salt, made highly diffusible by the peculiar attributes of oleic acid. Rubbed into the skin, the mercurial is absorbed as in the similar application of mercurial ointment, but more rapidly and thoroughly. Constitutional mercurialization is thus easily procurable. Lightly brushed upon a part, the preparation produces the local mercurial effects, and, because of its diffusibility, acts more thoroughly than do ordinary ointments or aqueous lotions. For destroying the vitality of the ova of lice, or of vegetable parasitic organisms, the preparation is unsurpassed. To produce constitutional mercurialization, the oleate is used in the same way as mercurial ointment. For such application the oleate is superior to the latter preparation in speed, effectiveness, and cleanliness; but being more irritant, it is liable to make the skin sore or even to raise an eruption. To neutralize this tendency so far as possible, a good plan is to order one per cent. of morphine—the pure alkaloid—to be dissolved by gentle heat in the oleate. For local effects the oleate of mercury is lightly applied to the part by a camel's-hair brush, and, if the skin be tender, morphine may be added, as just described.

Mercur-ammonium Chloride, NH_2HgCl. This salt, commonly known as *white precipitate*, is official in the United States Pharmacopœia under the title *Hydrargyrum Ammoniatum*, Ammoniated Mercury. The preparation is obtained by precipitating an aqueous solution of mercuric chloride by ammonia water in slight excess. Collected and dried, the precipitate appears as a white powder or pulverent lumps, odorless and nearly tasteless. It is permanent in the air, and insoluble in either water or alcohol. It should be kept in well-stoppered bottles, away from light. Ammoniated mercury is irritant and poisonous. It is used externally only for the usual purposes of the irritant mercurials, and almost invariably in the form of the official *ointment of ammoniated mercury*, consisting of ten per cent. of the salt incorporated with benzoinated lard.

Besides the foregoing official preparations, numerous others have been proposed, of which the more important are the following:

Mercurous Tannate. This salt forms by the action of tannic acid upon mercurous nitrate. It is of a greenish color, and resembles calomel in being insoluble in water or alcohol, and, accordingly, odorless, tasteless, and bland in local action. Its peculiarity is that it is easily decomposed by alkalies, however weak, and in such decomposition yields metallic mercury in exquisitely fine subdivision. Accordingly, when swallowed, it is decomposed by the alkaline contents of the duodenum, and offers mercury in a condition ready for absorption but yet not irritating. The tannate, therefore, is a possible bland mercurial for constitutional use, and may be prescribed as an antisyphilitic in doses of 0.06 gm. (gr. i.), in pill. The salt is incompatible with even the weakest of alkalies. Also, potassium iodide should not be given in conjunction.

Mercurous Bromide is a white, insoluble compound, for practical purposes a duplicate of calomel.

Mercuric Bromide is similarly a duplicate of corrosive sublimate. The bromides may be used in the same way as the corresponding chlorides, but present no advantages.

Mercuric Salicylate is an amorphous, white powder, insoluble in water or alcohol, and accordingly without odor or taste. It dissolves in solution of any of the alkaline chlorides, bromides, or iodides, such as, for instance, common salt. The salt has been proposed for internal giving as a constitutional mercurial, on the ground of being effective while but little disturbing to the digestive organs. It may be given in doses of 0.01 gm. (gr. $\frac{1}{6}$), in pill. Also it has been used as an antisyphilitic, by injection, hypodermatic or intramuscular, the powder being suspended in mucilage or paraffin oil. The mixture must be well shaken before use, and 0.01 gm. (gr. $\frac{1}{6}$) may be given at each injection.

Other preparations, proposed especially for hypodermatic use in syphilis, are as follows:

Mercuric Formamidate. A salt soluble in water, neutral in reaction, non-coagulating to albumin, and giving but little pain on injection. Dose for injection, from ten to twenty drops of a one-per-cent. aqueous solution.

Mercuric Benzoate. A white, crystalline salt, without odor or taste. Sparingly soluble in cold water, but soluble in hot water, in alcohol, and in an aqueous solution of common salt. Three parts of the benzoate and one part of common salt may be dissolved together in four hundred parts of water, and of this solution one (hypodermatic) syringeful may be injected daily.

Mercury Amidopropionate or *Alanate.* A white, crystalline powder, soluble in water. From 0.005 to 0.01 gm. (gr. $\frac{1}{12}$–$\frac{1}{6}$) may be given at each injection, in aqueous solution.

Mercury Sozoiodol. A fine, yellow powder, sparingly soluble, only, in water (1 part in 500) but soluble in solution of common salt. Dose for hypodermatic injection, 0.06 gm. (gr. i.). In strong solution, the compound is irritating. It is also employable locally, as a dusting powder, or in ointment of one or two per cent. strength.

Mercury Imido-succinate, or *Asparaginate.* A white, crystalline powder, soluble in 25 parts of water and in 300 parts of alcohol. Dose, by injection, 0.01 gm. (gr. $\frac{1}{6}$).

Mercury Succinimide. A white, silky powder, soluble in water, but almost insoluble in alcohol. Dose by injection, 0.01 gm. (gr. $\frac{1}{6}$).

For local use, the following have been proposed:

Mercury Pyroborate. An amorphous, insoluble brown powder. Used in ointment (two-per-cent. strength) as a dressing for syphilitic or other sores.

Mercury Stearate. A white, unctuous powder, for use as a dressing in place of ointment preparations.

Mercury-zinc Cyanide. A white powder, insoluble in water. Recommended by Sir Joseph Lister for use in antiseptic dressings. Its insolubility saves it from irritating and poisoning.

Compounds of mercury formerly official in the United States Pharmacopœia, and still occasionally used, are as follows:

Mercurous Oxide, Hg_2O. This is the compound commonly called *black oxide* of mercury. It is a dingy, dark olive powder, insoluble in water or alcohol. Its only use is in the so-called *black wash*, a mild mercurial lotion for syphilitic sores. This wash is practically mercurous oxide diffused through water. To obtain it, calomel is

mixed with lime water, generally in the proportion of 4 gm. (ʒ i.) of the former to 500 gm. (O i.) of the latter. Reaction occurs, the lime abstracting the chlorine from the calomel to form calcium chloride, which remains in solution, and giving oxygen in exchange, so that the white powder of the mercurous chloride changes to the dusky one of the oxide. On standing, the precipitate of the oxide rapidly settles to the bottom of the vessel containing the wash, so that the mixture needs to be shaken well before using.

Mercurous oxide is apt to form in small quantity in the trituration preparations of mercury described above, and some have thought that the activity of such preparations is wholly due to the presence of this compound, but this is undoubtedly not so.

Mercuric Sulphide, HgS. This is the well-known substance *cinnabar*, which, finely powdered, makes the pigment *vermilion*. It is a bright red substance, permanent, odorless and tasteless and insoluble in water or alcohol. It was formerly used for mercurial fumigation, by the plan of throwing about 2 gm. (gr. xxx.) on hot coals so placed that the resulting fumes should bathe the naked body of the patient, under an enveloping blanket. But the procedure develops sulphur dioxide gas which is highly irritating.

Cinnabar, accordingly, is now discarded, for use in fumigation, in favor of calomel.

Mercurous Sulphide, Hg_2S. This compound, long since abandoned as a medicine, needs mention only as being the mercurial formerly called the *black sulphide*, or *Ethiops mineral*.

III. General Therapeutics of Mercury Compounds.—As has appeared in the discussion of the several compounds of mercury, the therapeutic uses of the mineral are many and incongruous. Some of these are fulfilled by a single preparation only, but others, and the majority, are possible for several of the compounds. Concerning these latter some practical points present themselves for consideration.

Constitutional Mercurialization.—This procedure was formerly resorted to, in a routine way, in all cases of acute inflammations, especially of serous membranes, generally also in the continued fevers, and, in mild grade, in the various cachexiæ. Nowadays, however, it has fallen into disuse, except in the treatment of the single disease syphilis. In this affection its avail is most important, as will be found discussed in the article on *Syphilis*. General mercurialization can be effected by giving mercurials by the *mouth*, by *inunction*, by *fumigation*, and by *hypodermatic injection*. In general concerning these methods, the points may be noted that administration by the *mouth* is most convenient, is reasonably prompt and efficient, except in cases of most urgent haste, but subjects the digestive organs to a maximum of derangement. The *inunction* method is rapid and potent, peculiarly applicable therefore to urgent cases; saves the digestive organs, but is troublesome, dirty, and exposes the patient to detection of his malady. The *fumigation* process has all the features of the inunction method, with an extreme of troublesomeness. The *hypodermatic* procedure also is prompt, powerful, and saving to the digestive organs, but, with the preparation hitherto most used for the injection, corrosive sublimate, has the profound objection of being painful, and liable to produce abscess. To mercurialize by the *mouth*, if the object be a long-continued, gentle impression, mercury with chalk or blue mass, or small doses of the yellow iodide, are commonly selected from among the mild mercurials. For a less continuous action, but one still short of full therapeutic saturation, the *mercuric* compounds, chloride, iodide, or possibly cyanide, may be employed. Between the respective action of the two groups, the important points of difference are that the *mild* mercurials are most apt to salivate and provoke looseness of the bowels; and the *irritant* unduly to irritate the stomach. For the rapid production of the full limit of mercurialization by the mouth, the more potent of the mild mercurials—calomel, blue pill, or the yellow iodide—should be given in generous dosage. For rapid effect, however, mercurialization by other avenue than the mouth is theoretically preferable. For *inunction*, mercurial ointment and the oleate are the two available preparations, of which the latter is the more elegant and cleanly, but also the more irritating. For *fumigation*, calomel, and the black oxide are possible, but the first named is decidedly to be preferred. For *hypodermatic injection*, corrosive sublimate has been the preparation most used. By any method and for any purpose, modern practice enjoins that mercurialization must be limited in degree to the development of the mildest grade of stomatitis.

Digestive Disorders.—The correction of digestive disorders is one of the prominent applications of mercurials. The efficacy is one of wide range, and in it the antiseptic virtues of mercury probably play a part. The derangement in which the mineral has the oldest reputation is that whereof the main symptoms are constipation, with clay-colored stools, loss of appetite, with a bitter taste in the mouth, and perhaps even nausea, and a muddy or even distinctly jaundiced skin and conjunctiva. In such condition of things, as soon as a free passage from the bowels can be secured by a mercurial—calomel or blue pill, or, in the case of children, mercury with chalk—the various symptoms very commonly subside. And even if there be not constipation, mercury, now not necessarily in purgative dose, will still more often than not work a cure. Next, entirely apart from the matter of clay-colored stools, many cases of vomiting from digestive disorders, and, still more commonly, diarrhœal or dysenteric symptoms arising apparently from the same cause, are more or less controllable by mercurials. The selection is commonly calomel or mercury with chalk for vomiting, and mercury with chalk or corrosive sublimate for bowel affections. In all cases the dose is small, as, for instance, 0.01 gm. (gr. $\frac{1}{6}$) of gray powder, or 0.001 gm. (gr. $\frac{1}{60}$) of corrosive sublimate, frequently repeated.

The Killing of Parasites.—A purgative dose of calomel is anthelmintic, but it is particularly for the destruction of external parasites that mercury is used, a purpose for which mercurials are pre-eminent. The forms selected are usually corrosive sublimate in solution, white precipitate ointment, citrine ointment, mercurial ointment, or the oleate. The last named is the preparation to be preferred where the *ova* of lice are to be destroyed.

The Treatment of Skin Affections.—The surface disorders of syphilis are treated with great advantage by mercurials, locally applied, as an adjunct to constitutional treatment; but also non-syphilitic skin affections are often benefited by the same measures. Recognizing that the applications are irritant, the principle obtains to graduate the irritation of the application to the irritability of the part—a raw surface, tender and painful, taking a mild application, and an unbroken skin or an indolent ulcer a comparatively harsh one. In the order of their intensity of action, beginning with the mildest, the preparations in common use as local applications are as follows: *Calomel*, applied as powder or in ointment; *black oxide*, in the form of black wash; *mercurial ointment; ointment of the yellow oxide; ointment of the red oxide; ointment of ammoniated mercury; oleate; ointment of the nitrate;* lotions of *corrosive sublimate.*

The other prominent therapeutic uses of mercurials are generally unique, and the points concerning them have already been discussed in connection with the individual preparations.

Edward Curtis.

[1] Sternberg: American Journal of the Medical Sciences, April, 1883.

MERCURY, POISONING BY.—All the compounds of this element are violent poisons to all organisms whether plants or animals. Even in its elemental state metallic mercury is, under certain conditions, as will be seen, extremely poisonous.

The severity of the symptoms and rapidity of action in each individual case will of course depend upon the nature of the compound absorbed, the method of administration, size and frequency of the doses taken, and the

susceptibility of the victim; conditions which are of general application to all poisonings.

According to statistics collected by Kobert, ninety per cent. of the cases of poisoning by mercury are due to its administration in some form by physicians; the drug having been administered in too large a quantity at a single dose, or its use having been continued for too long a period of time, or, finally, there having been careless or excessive use of corrosive sublimate in antiseptic surgery. Criminal poisonings form about one per cent. or less of the cases recorded; while attempted suicide by means of mercurial products will claim about two per cent.

In the ordinary practice of a physician, poisoning from the following compounds of mercury may be encountered:

Metallic Mercury. Recent researches show that mercury vaporizes at all, save exceedingly low, temperatures. Even when in the solid state (− 39.4° C.) vapor is given off. Vaporization is not, however, readily detected until the temperature has risen to about + 5° C. Poisoning through breathing the vapors of metallic mercury is not uncommon, but cases of acute poisoning are rare. As examples of extensive poisoning by vapors of metallic mercury two famous cases may be cited. The first, that of the crew of H. M. S. *Triumph*, has become classical. This frigate sailed in 1810 with a cargo consisting chiefly of Cadiz mercury bound for the gold mines of South America. The ship having encountered rough weather part of the receptacles containing the mercury ruptured and several tons of the metal leaked into the hold. All animal life on board exhibited symptoms of mercurialism. The ship was picked up at sea in a helpless condition and towed into a French port. The crew of the rescuing vessel detailed to the *Triumph* were poisoned, as were also the men employed in cleaning her up when in port. In all two hundred men were afflicted with mercurialism; two died. The other case is that related by Kumnitz. In 1802 a fire broke out in the workings of the mercury mines at Idria, and as a result of the vaporization of mercury it is estimated that over nine hundred persons were afflicted with tremor mercurialis. One of the most remarkable cases of poisoning by vapors of metallic mercury is recorded by Faucher. A man and his wife in charge of a Parisian shooting gallery slept in a small room directly over the gallery, after having been in attendance all day. From two thousand to five thousand "Flobert" cartridges were shot daily. In the explosion of the fulminate of mercury with which these little cartridges are chiefly charged it is probable that mercury is set free and vaporized. The constant breathing of this mercury-charged atmosphere eventually led to chronic poisoning.

In connection with this discussion of cases of poisoning by vapors of mercury it is of interest to note that it is a quite well-established fact that persons exhibiting a tendency to phthisis are very susceptible to the action of these vapors and rarely recover from its effects, dying either from mercurialism or from tuberculosis.

The *pure* metal in the form of liquid seems to have only very slight action, often none at all. Fröhner has shown that dogs and swine can easily support doses of 250 to 500 gm. (½ to 1 lb.) without exhibiting any symptoms of toxic action. Similarly, enormous doses have been administered to man, in the early days of medicine, to remove obstructions in the bowels and as a cure for constipation, without any recorded evil effects. On the other hand, Gibb (*American Journal Medical Sciences*, 1873, p. 280) relates a case in which four and one-half ounces of metallic mercury were taken to procure an abortion (which, however, did not result) with the exhibition of serious symptoms of mercurial poisoning. Although liquid metallic mercury is generally inactive, if the metal is taken in a finely divided condition, as, for example, emulsified in fats, oils, etc., it becomes a most violent poison. The careless use of "blue ointment," "gray oil," "blue pill," etc., has led to numberless cases of serious illness. Leibling cites the case of three persons affected with the itch who rubbed into the body a mercurial ointment containing 270 gm. of finely divided metallic mercury. Death resulted in twenty-four hours from acute mercurial poisoning.

Mercuric Chloride. This salt, known under a variety of names, of which the most common is corrosive sublimate, occurs in the form of heavy, colorless, transparent, glistening, orthorhombic prisms which have an acrid, disagreeable, metallic taste. It is responsible for by far the larger number of cases of acute poisoning by mercury. It is soluble in water, the solubility increasing with the temperature, more soluble in ether, and still more soluble in alcohol and in glycerin. The solubility of mercuric chloride in water at ordinary temperatures is greatly increased by the presence of many substances, chief among which are the chlorides of ammonium, sodium, potassium and the alkaline earths, by camphor, etc. Practitioners are often too careless in the use of solutions of mercuric chloride in the dressing of wounds and in obstetrics. The excessive use of the usual strength of solution (1 to 1,000) has led to many sad accidents. Some patients are very susceptible to the action of mercury. The fatal dose of corrosive sublimate is not well established because of the variability of the intensity of its action on different individuals. It is probably safe to set it as low as 180 mgm. (2.78 grains). The variability of the fatal dose and fatal period is well shown by the following case quoted by Wormley. Three children were accidentally poisoned by mercuric chloride dispensed by mistake for calomel; one, seven years old, took eighteen grains (1.16 gm.) and died in three hours; another, two years old, took six grains (0.4 gm.) and died in eleven hours; the third, aged three, took twelve grains (0.78 gm.) but did not die until the twenty-third day. Severe symptoms have followed a dose as low as from one-third to one-half of a grain. Recovery has followed such enormous doses as 31 gm. (about ℥ i.), when there has been prompt and violent vomiting and subsequent treatment of the victim by a physician. Opium eaters are peculiarly resistant. Rigler states that a certain individual addicted to this habit was able to take 1.8 gm. (gr. xxviij.) daily without illness.

Mercuric Cyanide. This salt is met with in the form of more or less transparent, colorless, prismatic crystals, often slightly darkened by exposure to light. It is odorless and has a bitter, metallic taste. It is soluble in water and in alcohol, but only very slightly soluble in ether. This salt has occupied a relatively insignificant place in the toxicology of mercury until the recent Molineux case in New York City forced it into prominence. The fatal dose of the salt is probably less than that of the chloride because of its greater solubility in water and the ease with which it is decomposed with the formation of hydrocyanic acid. In some of the cases recorded death seems to have been due to the action of cyanogen compounds rather than to that of mercury. Death is not, however, always rapid. In one instance 600 mgm. caused death in nine days; in another instance 1.2 gm. also caused death in nine days.

Mercurous Chloride. Calomel occurs in commerce as a heavy, white powder with a yellowish tint, without odor or taste, almost insoluble in water, insoluble in alcohol and in ether. It is slowly acted upon by light and slowly decomposed by boiling water, metallic mercury and corrosive sublimate being among the products formed. Its solubility in water is increased in the presence of alkaline chlorides, corrosive sublimate being formed. Perfectly pure calomel is of very low toxicity in the case of man, but Fröhner has shown that with herbivorous animals, especially ruminants, this salt is quite poisonous: 8 to 10 gm. (ʒ ij.–iij.) produce very serious effects on young cattle; a dose of 20 gm. (about ʒ v.) is toxic to horses; 5 gm. (gr. lxxvij.) are toxic to sheep; while dogs and swine are relatively resistant per kilogram weight, the toxic dose being from 2 to 10 gm. (gr. xxxi.–cliv.). Because of the ease with which calomel is acted upon by many substances, with the formation of the actively poisonous mercuric salt, accidents due to such incompatibles are not rare. There are also on rec-

ord numerous cases of mercurial poisoning due to the administration of impure calomel.

Iodides of Mercury. The mercurous salt is of no clinical importance. The mercuric salt, of but little more importance, is met with under two modifications: the yellow and the red, the latter being the stable form. Mercuric iodide is moderately soluble in water (1 in 160), more soluble in the presence of hydrochloric, of hydrobromic or of hydriodic acid, of ammonium salts and of the chlorides and bromides of the alkali metals; it is very soluble in solutions of the iodides of the alkalies. This salt is a very powerful poison and in some respects is comparable with mercuric chloride. On animals it acts with great violence. A salve containing 5 gm. (gr. lxxvij.) has caused the death of a two-and-a-half-year-old bull.

Oxides of Mercury. Mercuric oxide is met with in two forms: the yellow oxide prepared in the wet way and the red oxide prepared in the dry way. The yellow is considerably more active and more soluble than the red. Its solubility is, however, very low, being about 1 part in 20,000 of water at ordinary temperatures. Because of its use in medicine a few accidents have resulted. In doses of about 500 mgm. (about gr. vij.) severe symptoms have been observed. The fatal dose can probably be set at from 1 to 1.5 gm. A dose of 30 gm. has caused death in forty-eight hours.

Other Compounds of Mercury.—Mercur-ammonium chloride, white precipitate, is a heavy, white powder, frequently employed in medicine. It is insoluble in alcohol and in ether, and although practically insoluble in water it has led to several cases of poisoning. Doses of from 1.9 to 2.6 gm. (gr. xxx.–xl.) have produced dangerous symptoms, and 7 gm. (gr. cviij.) have proved fatal in eight days.

Of the sulphates of mercury only one is of clinical interest—the Basic Mercuric Sulphate (Hydrargyri Subsulphas Flavus, U. S. P.). This heavy, lemon-yellow, odorless powder possesses a slightly acrid metallic taste, is insoluble in alcohol and slightly soluble in water (1 in 2,000), more soluble in boiling water. This salt, sometimes called turpeth or turbith mineral, caused the death of an adult in eleven days in a dose of 2.6 gm. (gr. xl.), and in another case 3.9 gm. (gr. lx.) it proved fatal to a boy of sixteen in seven days.

The sulphides of mercury are so insoluble that they are sometimes said to be non-poisonous. The red sulphide, vermilion, is known, however, to have been responsible for cases of chronic poisoning in France, due to its presence in cosmetics.

Mercuric Nitrate is responsible for a number of cases of poisoning in the form of the so-called "acid nitrate," a solution of high specific gravity, formerly much employed in Europe as an escharotic. Tardieu records a case in which death resulted in about two hours after swallowing a quantity of this corrosive liquid. Most of the cases of poisoning, however, are the result of its use as an escharotic.

The Sulphocyanate of Mercury which serves as the basis for the manufacture of Pharaoh's serpents possesses such energetic emetic powers that there is little danger to be apprehended from its ingestion. When administered to non-vomiting animals it produces all the symptoms of mercurial poisoning. For further information concerning this interesting salt the reader is referred to the investigations of Ouchinsky (*Ann. d'Hyg. et de Méd. lég.*, 3, xxix., 347), and also to a communication of Brouardel et Ogier (*Ann. d' Hyg.*, 3, xxix., 352). In the burning of the "serpents," vapors of metallic mercury are produced which may lead to evil results in small, ill-ventilated rooms.

Symptoms of Poisoning by Mercury.—Cases of mercury poisoning fall into one of three groups or classes: acute, subacute, or chronic. In the first class fall all those resulting from a large dose or several rapidly taken moderate doses of a readily soluble salt of mercury; the action being, in a general way, that of a violent irritant poison, or of a corrosive; death taking place in from twenty-four to thirty-six hours. Subacute cases result from a somewhat slower action, the primary symptoms are not so violent and the period of illness is quite long. This second form is seen when the dose is smaller than in the first form, when small doses have been administered in too rapid succession, and when the compound taken or absorbed is not easily soluble. The fatal period varies from five to twenty days, or is often even longer; cases under eight to ten days are generally the after-result of acute poisoning. The cases classed as chronic need no explanation; they are the result of "industrial poisoning" or of medicinal poisoning due to excessive prolongation of mercurial treatment. The symptoms do not appear for weeks or even months. Death may sometimes result, but recovery usually follows the removal of the cause.

Acute Poisoning.—This is generally the result of swallowing corrosive sublimate. Immediately after taking the poisonous substance there is experienced by the victim an intensely disagreeable, acrid, metallic taste followed almost at once by a burning sensation (increasing to pain) in the mouth, throat, and epigastrium; this pain rapidly extends with increasing severity to the abdomen. There is excessive thirst. Nausea sets in, followed by frequent retching and vomiting of mucus often tinged with blood and sometimes containing shreds of mucosa. There is diarrhœa with frequent serous, mucous, and usually bloody stools. The pulse is small and frequent. The body of the victim is bathed in a cold perspiration. The victim exhibits great anxiety. The mucosa of the mouth and throat is white and shrivelled and in a short time there is severe swelling of the fauces. Often the swelling of the throat is so severe as to threaten asphyxia, and cases are known in which tracheotomy became necessary to save life. Breathing becomes difficult and dyspnœic. A period of vertigo precedes insensibility, collapse, and death. Death may sometimes occur in convulsions. The fatal period is from twenty-four to thirty-six hours. The shortest time on record is a case recorded by Welch in which death took place in thirty minutes after swallowing the poison.

Subacute Poisoning.—The dividing line between acute and subacute cases is very vague, the former merging into the latter. Thus a case of acute poisoning in which life is prolonged may pass into the subacute stage. In addition to the general symptoms just given, there are seen the characteristic symptoms of poisoning by mercury. The vomited matter is thick, viscid, bilious in character, eventually becomes bloody and has a bad odor. The abdomen is usually, but not always, tense and painful to pressure. The face is alternately pale and flushed and expresses suffering, anxiety, and prostration. The sweat-covered body is without strength. The gums are inflamed, swollen, and painful. There is constriction of the throat, more or less severe cough, often with the expectoration of bloody matter. The breath is very fetid; the odor is peculiar, characteristic, and of great diagnostic value. The swelling of the gums is accompanied by sensitiveness of the teeth, which become loosened and may even be shed. Stomatitis is followed by salivation, becoming at times excessive. The saliva has the same characteristic fetid odor as the breath. Colic is followed by frequent, very painful (tenesmus) bloody stools, closely resembling those of dysentery. This diarrhœa differs from that resulting from poisoning by arsenic, antimony, etc., in that the stools are, as a rule, more frequent, smaller, and composed chiefly of mucus tinged with bile and blood. There is generally complete or almost complete anuria; when the urine is not entirely suppressed it is albuminous. There may or may not be slight jaundice. In very protracted cases there is apt to be a weakening of the intelligence, a loss of muscular power, more or less marked œdema accompanied by paralysis of the lower extremities; and an eruption on the skin, eczema impetiginosum. The temperature is normal or only very slightly raised, until the approach of death, when it is apt to fall with great rapidity. The pulse is small, weak, and thready. The skin of the patient feels cold and clammy. The respiration is

generally dyspnœic and asthmatic. A period of apparent convalescence may intervene after five or six days, the pulse increases in strength, the body warms up, the skin loses its clammy feeling, respiration becomes more regular and normal. This period of reaction is quickly followed by relapse, the patient falls into a state of great prostration, the pulse becomes small, weak, and imperceptible; there are syncope, loss of sensation, and coldness of the lower part of the body; there is more or less marked loss of speech, but the patient remains lucid to the last. Sometimes there is internal hemorrhage from the bowels, stomach, etc., accompanied by a great fall in temperature; Loewy records a case exhibiting a sudden fall of temperature to 33.4° C. (92.1° F.). The average fatal period is from eight to fifteen days.

The channel of introduction of the poison modifies slightly the symptoms observed. For example, poisoning from the excessive use of mercuric chloride in childbirth does not give rise to the acute stomatitis (stomatitis ulcerosa) seen in the introduction of the poison per os, though more or less inflammation and swelling are exhibited no matter what the channel of absorption. Toxic gastritis and enteritis also result from the introduction of mercury into the body no matter what the method of entrance.

Chronic Poisoning.—Chronic mercurialism is the result of constant exposure of the body to contact with mercury in some form, or to the frequent ingestion of mercurial remedies prolonged over a long period. In the arts, several industries give rise to chronic poisoning of workmen, as, for example, the mining of ores of mercury and the extraction of the metal from them; the manufacture of mirrors and of various preparations and salts of mercury; electrotyping, gilding; the manufacture of certain kinds of felt, of barometers, thermometers, and other instruments necessitating the use of mercury; the manufacture of fulminate of mercury and of percussion caps, etc., etc. Of these industries the most harmful are doubtless the mining and extraction of the metal. According to the statistics collected by Kobert, in the best ventilated and hygienically constructed and operated mines from one to two per cent. of the miners are afflicted with mercurialism; while in the extraction of the metal by heat fully eight per cent. of the workmen exhibit typical symptoms of chronic poisoning.

In chronic poisoning by mercury practically all the symptoms accompanying the subacute cases are seen but in a less aggravated form, and in addition there are several distinct and characteristic symptoms. First of importance among these characteristics must be placed tremor mercurialis. This affliction appears as an extraordinarily severe trembling of the patient, in which the upper parts of the body, especially the arms, are first affected. The movements of the lips and tongue are also altered so that speech may become confused and unintelligible. Tremor, as has been said, is most noticeable in the arms where it is almost convulsive in character and renders them vacillating. The seizures are brought on by any attempt at muscular effort and are often so severe as to necessitate the feeding of the victim. When the muscles are relaxed and the patient is quiet, only a twitching is observed, while during sleep no sign of tremor is seen. Children born of parents afflicted with tremor mercurialis have been known to exhibit tremor, but in the majority of cases chronic poisoning leads to abortion. Accompanying tremor there is well-marked erethismus tending to aggravate the seizures of trembling. Resulting from anæmia and gastric and enteric catarrh mercurial cachexia makes its appearance; this is seen in the anæmic condition of the blood, the atrophy of the muscles, and the general wasting away of the body. Salivation is usually excessive, several gallons of saliva have been secreted daily by some patients. The specific gravity of the saliva secreted in the early stages of the disease is usually abnormally high, due to the presence of albumin; later, however, it falls again to the normal value or may be subnormal. Salivation is not a primary symptom but follows stomatitis and may disappear in very protracted illness. The gums are swollen, soft, hemorrhagic, and usually painful; often they show a dark line somewhat similar to that seen in chronic poisoning by lead. The breath is very fetid. Carious teeth decay with great rapidity, sound teeth are painful and loosened, and may even be shed. Necrosis of the jaw not infrequently results. The skin is more or less seriously affected, as shown by an eczematous appearance—eczema impetiginosum, or squamosum (eczema mercurialis)—or in more mild cases by urticaria. There may be falling out of the hair. The patient suffers from albuminuria, generally from obstinate and almost complete anuria, and is afflicted with mercurial cirrhosis of the kidneys. Often a distressing tuberculosis-like cough is heard. Lastly, in very protracted cases many authorities believe that there results decalcifying osteitis, but upon this point there is some dissent; the weight of evidence, however, seems to show that calcium salts are withdrawn from the bones and deposited in the kidneys.

Evidence has been adduced at different times to show that the progress of the disease is more rapid in women than in men; however this may be, it is certain that some individuals are much more sensitive to mercurial action than others, and that persons having a tendency to tuberculosis rarely recover from chronic mercurial poisoning.

Children born of parents suffering from mercurialism are generally weak, frail, and show a decided tendency to tuberculosis.

Post-mortem Appearances.—The symptoms exhibited in poisoning by mercury have been described in sufficient detail to indicate the chief pathological changes which will be seen in an autopsy. These changes are generally sufficiently characteristic to enable an expert to assert with a fair degree of confidence that death was due to mercurial poisoning.

The whole alimentary canal is more or less inflamed; the mucosa of the mouth and throat is red or even ulcerated, especially in the upper part, or in very acute cases it may be shrivelled and whitened; that of the stomach is ecchymosed, even ulcerated; in only one case has perforation been observed. The intestines are more strongly affected than is the stomach and may exhibit greenish-yellow ulcerations, especially in the lower part of the ileum; not infrequently the mucosa is œdematous, swollen, and the submucosa infiltrated with serum. In such an event the intestines are anæmic. These appearances follow the absorption of mercury by no matter what channel; and, save the whitening of the mucosa, are not confined to per os ingestion. Usually the large intestine exhibits macro- and microscopic appearances identical with those seen in dysentery. The liver and kidneys are anæmic, enlarged, and show fatty degeneration unless death has been quite rapid. The liver may be icteric and pasty. Microscopic examination of this organ shows numerous fatty droplets and granulations in the cells in which the nuclei have been destroyed. The kidneys exhibit a somewhat analogous appearance which may sometimes be suggestive of Bright's disease. Sections of the kidneys (in subacute and chronic poisoning) placed under the microscope and treated with dilute sulphuric acid will be seen to give off a gas—carbon dioxide—due to the presence of deposits of carbonate of lime, and in a few seconds the tubuli will be seen to be clogged with characteristic acicular crystals of calcium sulphate formed by the action of the sulphuric acid. The bladder is contracted and usually empty. The muscles of the heart are hemorrhagic and show some fatty degeneration. This steatosis of liver, kidneys, and heart is analogous to that observed in cases of poisoning by arsenic and by phosphorus, but is not quite so severe as in these cases. The lungs are sometimes normal, more often full of blood, the result of bronchopneumonia. The muscles of the body are anæmic with here and there ecchymosed spots; incisions made in the muscles lead to the exudation of a watery fluid. The blood in acute cases is usually dark, thick, and coagulates with difficulty. In chronic cases it is anæmic. The mouth may appear grayish in color; this appearance occasionally ex-

tends down the œsophagus. The walls of the intestines are not infrequently grayish or blackish from mercuric sulphide, the result of putrefactive changes. In a few instances it has been thought that this gray color has been the result of the deposition of very finely divided metallic mercury.

Antidotes.—The only satisfactory antidotes are albumen, such as white of egg, milk, flour and water, etc.; ferrous sulphate with reduced iron or ferrous sulphide; followed immediately by the stomach pump or emetics and purgatives, unless such action has already been induced. Prompt removal of the material from the alimentary canal is imperative, since the insoluble compounds of mercury produced by the action of the antidotes are all more or less rapidly acted upon by the fluids of the body. The administration of too great an amount of albumen is also probably objectionable, as there seems to be good reason for believing that the compound of mercuric chloride with an excess of albumen is more soluble than when the albumen is not in excess. It is better, therefore, to administer only just the amount which it is judged will render the poison insoluble; then remove the precipitate and administer a fresh dose of the antidote. The white of one egg will render about 260 mgm. (gr. iv.) of mercuric chloride inactive. Stomatitis is best treated by frequent gargles or washes of potassium chlorate. In the treatment of chronic poisoning zinc phosphide has given excellent results. Tremor mercurialis can be more or less successfully treated with electricity. There is at present much diversity of opinion as to the value of iodides and of sulphur compounds such as flowers or liver of sulphur, sulphureted hydrogen waters, etc. There are reasons for believing that although good results have, in many cases, followed the use of these disputed remedies, their efficacy has been somewhat overestimated.

All rooms and buildings, etc., in which either metallic mercury or its salts are employed should be exceptionally well ventilated and every possible precaution should be exercised to avoid spilling material on the floors, workbenches, etc. The most scrupulous cleanliness of all workmen should be insisted upon. The floors of the rooms should be free from all fissures and cracks and should slope gradually from all sides toward the centre in order to facilitate cleaning. Meyer has suggested the sprinkling of the floors with dilute ammonia each day after the day's work is done.

Elimination.—Mercury seems to be eliminated from the body through all the secretions, but chiefly by the glands of the stomach and intestines in the fæces, by the kidneys in the urine, by the salivary glands in the saliva, and by the liver in the bile. For the clinical detection of mercury either the urine or the saliva may be employed. In acute cases the greater part of the poison will be ejected in the vomited matter.

Mercury is known to persist in the body for long periods after all ingestion has ceased. The usual period of elimination in acute poisoning by corrosive sublimate is probably about thirty days, but the metal may persist for months. In subacute cases the period of elimination is thought to be about six months; while following chronic poisoning, mercury is slowly eliminated from the body during periods of almost incredible length. Ogier cites a case communicated by Vadja and Pachkis in which mercury could be detected in the urine thirteen years after the cessation of mercurial treatment!

According to Hoffmann, when vapor of metallic mercury is inhaled there is observed the elimination of free metallic mercury in the urine; several other experimenters have observed the same phenomenon.

Mercury seems to possess a marked cumulative action and is localized chiefly in the liver and kidneys, from which organs it disappears only very slowly. It can be detected in the liver, in most cases, after it has disappeared from other organs of the body.

Action on Animals.—Animals poisoned by compounds of mercury exhibit symptoms similar to those described above for man—namely, stomatitis, salivation, catarrh of the stomach and intestines, cough, eczema, apathy, tremor, cachexia, emaciation and death in coma, more rarely in convulsions, in a few hours or in from ten to fourteen days.

Mechanism of the Action of Mercury.—Science has not yet reached a stage where we can formulate a satisfactory theory for the cause of the action of mercury. Lack of space forbids a discussion of the various hypotheses which have been advanced; suffice it to say that none of them is wholly satisfactory. All that is possible is to glance hurriedly and in a very general way at the mechanism of the action.

Owing to the great affinity of mercury for the nitrogen compounds of the tissues, albuminates of mercury or analogous combinations are formed, causing the death of the cells. This layer of destroyed cells is not impermeable but allows deeper and deeper progressive action, due in part to the penetration of a fresh supply of the poison or to the resolution of the mercury in the albuminate first formed. It is probable that the mercury circulates in the blood in the form of what has been called mercuric chloride-albuminate or sodium chloride-mercuric-albuminate, soluble compounds of unknown composition. The result of the circulation of these poisonous compounds is the death of cells, etc., as shown by the progress of the disease in stomatitis, gastritis, enteritis, salivation, and, even in the early stages, in ulceration of the glottis. That these symptoms are not the result of contact but are of secondary action through the blood is proved by the fact that they appear when mercury is applied externally (ointment) or injected subcutaneously and when only the faintest trace of mercury has reached the intestines. In circulating through the liver the mercury produces an abnormal secretion of bile, accompanied, according to some investigators, by the destruction of countless blood corpuscles, the latter being deposited, so to speak, in this organ, and giving rise to its fatty infiltration, and to anæmia and cachexia. An analogous action takes place in the kidneys where the changes produced in the tubuli give rise to albuminuria. In a short time after circulating through the body mercury causes more or less marked paralysis of the muscles and of the heart; this Rabuteau believes to be due to the destruction of the contractility of the muscles without any action on the motor nerves. According to this view the cardiac paralysis observed soon after the administration of a very large dose is due to the loss of contractile power of the cardiac muscles and is not the direct result of neural paralysis. The experiments of von Mering have shown that mercury exerts a decided and very deleterious action on the vaso-motor system and on the heart. In prolonged illness there can be no doubt that mercury exerts a specific action upon the central nervous system; since we observe erethismus mercurialis and a weakening of the intelligence, perhaps the tremor can be ascribed in part to this action. One of the most remarkable of the effects of mercury is that of the dissolving of calcium salts in the bones, to which reference has already been made; the lime thus extracted is eventually deposited, in part at least, in the kidneys, apparently as the carbonate, clogging the canals (see von Weichselbaum, *Centralbl. f. Path.*, 1891, 1). How and why this action is brought about is unknown.

Kaufmann believes death to be the result of primary intravital multiple capillary embolism in the kidneys and that this is shown in epithelial necrosis, calcification, and capillary thrombosis. Jolles, on the other hand, believes death to be the result of capillary embolism, not in the kidneys but in the intestines.

Clinical Tests for Mercury.—The urine and the saliva are the most satisfactory materials upon which to work. In case the urine is employed it is best to concentrate it to about half its volume. Acidify the solution to be tested with pure hydrochloric acid. Introduce two or three tiny strips of pure bright copper foil about 1 mm. wide by 3 or 4 mm. long. Heat almost to boiling for from ten to fifteen minutes. Pour off the liquid from the foil and wash the latter first with water, then with alcohol, and dry

by pressing gently between sheets of filter paper. If mercury is present the copper foil will be coated with a gray or silvery film. A gray film gently rubbed with the end of a finger becomes bright and silvery. The mere deposition of a film upon the copper should not be taken as conclusive evidence of the presence of mercury. In order to confirm the presence of this element the perfectly dry foil can be introduced into a small glass tube closed at one end. The tube should then be heated at a point from about 3 to 5 cm. above the roll of copper foil and drawn out to a bore of say 2 mm., care being taken to avoid heating the bit of coated copper. When the tube thus prepared is perfectly cold, the end containing the foil is heated red hot in a Bunsen or alcohol lamp. The mercury amalgamated with the copper is thus vaporized and condenses on the walls of the tube; by progressively heating the tube above the foil all the mercury is driven into the constricted part of the tube and an examination with a microscope or pocket magnifier will disclose many tiny silvery globules of metallic mercury. In case the globules are very minute, rubbing the deposit with a fine iron wire or with a drawn-out glass rod will cause them to unite into globules large enough to be readily detected. Although this reaction is a very delicate one, it can be rendered even more delicate by converting the sublimate of mercury into red mercuric iodide. This is accomplished by proceeding as follows: The closed end of the tube is cut off, a small fragment of iodine introduced, and the end of the tube closed with a tiny cork. Thus prepared the tube is laid in a warm place for half an hour or more. The slow vaporization of the iodine causes the formation of brilliant red mercuric iodide, which is generally easily visible to the naked eye if the tube be held over white paper. Too high a heat will cause the sublimation of much iodine, thus masking the red color of the iodide. In such an event a gentle current of air drawn or blown through the warm tube will remove the iodine. By this iodine method 0.1 mgm. of mercuric chloride can be detected with ease, and with great care the delicacy can be pushed to beyond 0.01 mgm.

Instead of copper foil a little spiral of thin pure gold foil (dental foil) can be wound around a tiny rod of metallic tin or zinc. The electrolytic couple thus obtained is dropped into the acidulated liquid to be tested. No heating is necessary. After several hours the couple is removed, washed, dried, and heated in the manner suggested above. Most of the mercury amalgamates with the gold, but a part is always deposited upon the tin or zinc; hence after carefully unrolling the gold each part of the couple should be tested.

Another method consists in winding a spiral of platinum foil around a common steel sewing needle, introducing this couple into the liquid and proceeding as described above.

A very convenient arrangement when employing a couple is to drop it into a separatory funnel of suitable size, pour in the acidulated liquid, and open the stopcock so that tiny drops fall very slowly. To make doubly sure, the liquid can be poured back and again allowed to come in contact with the couple.

Solid organic matter can be brought into solution by treating with hydrochloric acid and potassium chlorate on the water-bath. The strongly acid solution thus obtained can be partly neutralized with sodium bicarbonate and tested for mercury by any of the above-mentioned methods. *Emile Monnin Chamot.*

MESCAL (OR MUSCALE) BUTTONS.—*Anhalonium. Pellote.* The dried tops of several species of *Lophophorus* (*Anhalonium*), especially *L. Williamsii* (Lem.) Coulter and *L. Lewinii* (Henning) Rusby.

These cactuses grow in high, arid mountain localities of Northern Mexico, and probably also in the adjacent portions of the United States. The stem is mostly subterranean, its upper portion projecting slightly above the surface as a flat disc, roughened with triangular, thick, short, fleshy lobules and bearing in the centre a mass of bristly whitish hairs, in which the small pink flowers are partly concealed. These tops are sliced off and dried, which causes them to shrink to button-shaped discs, one or two inches broad and from an eighth to a quarter of an inch thick. These dics constitute the commercial drug. They are wrinkled underneath and bear above the dried fleshy lobules and the central mass of hairs. In this condition, the withered flowers are scarcely discernible, except after soaking. In the first-named species the hairy tufts are somewhat separated, while in the second they are matted together and less white. The first-named species contains nearly one-half per cent. of the alkaloid *pellotine* ($C_{13}H_{19}NO_3$). The second contains a smaller total of the four alkaloids, *anhalonine* ($C_{12}H_{15}NO_3$), *mescaline* ($C_{11}H_{17}NO_3$), *anhalonidine* ($C_{12}H_{15}NO_3$), and *lophophorine* ($C_{13}H_{15}NO_3$). The Mexican aborigines use this substance as a powerfully narcotic intoxicant, the effects apparently much resembling those from the use of Indian hemp. Ceremonial assemblies are held, at which each participant chews one or more of the "buttons," passing at length into a trance-like state, productive of strange intellectual experiences. Occasionally, when an unusual amount is ingested, the subject does not recover, death resulting.

Nixon found all the alkaloids of *L. Lewenii* to act similarly, being non-irritant, sialagogue, constipating in small doses, apt to be purgative in large ones, which were apt also to cause nausea and vomiting, these results occurring from either gastric or hypodermic administration. Small doses greatly strengthen and, for a time only, accelerate the heart's action, and increase arterial pressure; toxic doses paralyze the vagal endings and later the nerve cells. They also produce a rapid and shallow breathing, death, when it results, being due to respiratory failure. There is a primary stage of exhilaration and talkativeness, followed by complete intoxication. The pupils are now dilated, there is increased reflex activity, but with blunting of cutaneous sensitiveness, and there are auditory and nasal hyperæsthesia, inco-ordination and trembling, hallucinations, especially of vision, with kaleidoscopic play of colors and a rapid flow of ideas, without control. Intellection and introspection appear normal, but dual existence is sometimes imagined. Lewin found the toxic symptoms in rabbits to be similar to those from strychnine. Cushney regards the mescaline as the exhilarating constituent, pellotine as the hypnotic. The medicinal uses of anhalonium have been but little developed. Beneficial effects have been secured from its administration as a cardiac and respiratory stimulant in asthma, from two to five minims of the fluid extract being administered. Anhalonine and pellotine have also been administered for the same purpose, in doses rather smaller than those of strychnine. *Henry H. Rusby.*

MESENCHYMA is a term introduced by the brothers Hertwig to designate the non-epithelial portions of the mesoderm. The mesenchyma develops into a great variety of important tissues, so that a knowledge of the histogenesis of the mesenchymal derivatives is indispensable for the pathologist. From the mesenchyma of the embryo arise the connective tissues, the supporting tissue (cartilage and bone), the lymphoid tissue, Wharton's jelly, blood-vessels, blood, lymph vessels and glands, wandering cells, fat cells, pigment cells, marrow, and smooth muscle fibres. The embryonic mesenchyma consists of more or less widely separated cells connected by intercellular bridges of protoplasm and embedded in a highly transparent homogeneous matrix; it is always covered by epithelium, which may be either ectodermal, mesothelial, or entodermal, according to the location of the tissue. See *Embryos* and *Germ Layers*.

Charles S. Minot.

MESENTERY. See *Abdomen.*

MESODERM is the middle layer of the body of the embryo (see *Fœtus* and *Germ Layers*). Mesoblast is also used as a synonymous term; sometimes, however, the term mesoblasts is applied to the large cells in the segmenting ova of certain lower animals, from which the mesoderm

proper is produced. A few writers have sought to alter the application of the term mesoderm, but it is almost universally used as above described, and to use it otherwise would now cause unnecessary confusion.

C. S. Minot.

MESOTHELIUM is a term introduced by Minot to designate the epithelial portions of the mesoderm, which line the body cavity; *cf. Cœlom,* including the myotomes (*protovertebræ, auct.*).

METABOLISM.—Incessant chemical change is a characteristic of living substance. It matters not whether we are dealing with an individual cell or with the complicated groups of cells which make up the higher organisms,—in any case activity is associated with a transformation of the complex molecules which build up or are associated with the protoplasm. The expression *metabolism*—or *Stoffwechsel* of the Germans—is used to include the sum total of the chemical exchanges which take place in living organisms. In this broad sense it embraces the transformations which unorganized materials introduced into the body undergo, as well as the chemical processes connected with the various tissues and organs themselves.

The active cells and the living body are not in a state of continued stable equilibrium. Processes of growth and repair occur side by side with the disruption of elementary tissue substance. The term *anabolism* (assimilation) refers to the integrative or constructive changes by which either living protoplasm or new compounds are built up out of simpler materials; while by *katabolism* (dissimilation, disintegration) is meant the series of processes which result in the breaking down of the fixed constituents of the organism. Thus analysis and synthesis may play their part coincidently or successively in the various phases of the activity of the living substance; and when the effects of destructive or katabolic change are no longer offset by appropriate anabolic processes, the functions may become impaired or may cease altogether. Indeed, the continuity of life has been said to depend upon perfect metabolism.

The general features of metabolism may be illustrated by reference to the higher animals. Incidental to the liberation of energy in their bodies, waste products are formed and eliminated by way of the lungs, kidneys, skin, and intestine. Excretion is thus, broadly speaking, a feature of katabolism, the details of which are discussed in other parts of this HANDBOOK. The losses which the body undergoes in the expired air, urine, perspiration, fæces and otherwise, are repaired by the alimentary processes, digestion, absorption, etc., which are likewise more appropriately considered by themselves (see *Digestion, etc.*). The facts noted serve, however, to emphasize the importance which the study of nutrition has for a correct understanding of metabolism in the wide sense in which it is here used. The materials utilized must be replaced; intake of matter succeeds output, and accordingly compounds related to the body constituents—the foodstuffs—are taken up by the animal and prepared for assimilation. By *nutrition* the losses of the body are made good and a normal condition of life and growth is maintained.

It will thus be seen that metabolism, in its entirety, consists of a series of complicated processes. In plants the synthetic changes predominate, and highly complex compounds are built up almost directly from the elements. In animals, on the other hand, katabolism largely prevails. Our acquaintance with synthetic processes in animal organisms has, however, been extended greatly in recent years; so that the physiologist of to-day is inclined to point out differences quantitative rather than qualitative in kind, between the life of plants and that of animals.

The chemical changes which the living substance or included materials (food, drugs, etc.) most commonly undergo in the metabolism of the animal body are: cleavage and oxidation. The foodstuffs, for example, entering the organism in the form of complex molecules of carbohydrate, fat, and proteid, undergo a more or less complete combustion. Oxygen unites with carbon to form carbon dioxide and with hydrogen to form water; the nitrogen of the highly complex proteid substances reappears in combination with carbon, hydrogen, and oxygen as urea, uric acid, hippuric acid, etc.; the sulphur and phosphorus of organic compounds are eliminated after oxidation to sulphuric acid and phosphoric acid. The final conversion of the ingesta is, then, on the whole, an oxidative process, although synthetic and reduction processes may occur at various intermediate stages. It is through the katabolic processes just described that the potential energy of the foodstuffs is ultimately transformed to maintain the temperature of the body and accomplish its work. In the cleavage of complex compounds to simpler ones part of the potential energy of the ingested food, perhaps stored up temporarily in the form of glycogen or tissue fat, becomes kinetic. In some cases the combustion proceeds to the same end-products which arise by oxidation outside of the body; or, again, the compounds which are discharged by the elimination of the products of katabolic changes may be incompletely oxidized or even undergo subsequent synthesis, as is true of such substances as urea and hippuric acid. The burning up of coal in the steam-engine involves a relatively simple and distinct process. Quite different are the comparable changes in living organisms. Here the materials which serve as the source of energy are liable to undergo a whole series of transformations of distinct and varying chemical character. In some cases, for example, the materials are to be utilized in the liberation of heat, while in others they may become in part adapted to renew the structure of the tissue,—to replace the worn-out parts of the machine, as it were. However obscure the knowledge of the intermediate processes here involved may be at present, it is certain that animal heat, protoplasmic movement, muscular contractions, and electrical phenomena are all referable in origin to the metabolic processes mentioned above.

It was formerly believed that the bulk of the oxidative changes in the animal body takes place in the blood and tissue fluids. The promulgation of the cellular theory in biology gave a new trend to observations on the animal functions. While admitting that oxidation may occur to some extent in the circulating medium, the physiologist is inclined to-day to look upon the tissues as the chief seat of the metabolic changes. The component cells, rather than the tissue fluids, are the laboratories in which the specific chemical reactions are carried out; and thus it is possible to understand how processes of widely differing character—hydration and dehydration, oxidation and reduction—may proceed simultaneously, yet independently, in the complicated structure of the protoplasm. Numerous experiments speak against the importance of the blood for the physiological oxidations which take place in animals. Thus in frogs and rabbits only slight alterations in these processes have been observed after removal of large portions of the circulating medium. Easily oxidizable substances like lactic acid, which are scarcely affected by direct contact with blood, are readily transformed when surviving organs are perfused with blood containing them. A good illustration of this is obtained by passing blood in which uric acid is dissolved through the isolated liver of mammals. The uric acid is decomposed through the agency of the living cells. With blood alone little change occurs; it is merely the intermediator by which oxygen is conveyed to the active tissue. In general, then, the changes which the blood itself undergoes in its transit along the vascular channels form only an insignificant part of the total metabolic transformations which go on.

It may be well to point out here a further peculiarity of animal oxidation. The reaction with the respired oxygen is by no means a direct one. The products of metabolic activity in the organism indicate clearly that the chemical changes are not dependent on a natural affinity between the oxygen and the organic compounds of the body. The combustions in the organism in many

cases proceed at a temperature at which no reaction can be brought about with oxygen outside of the body. It is only necessary to recall the readiness with which fats are completely burned up in animals, whereas in the laboratory such compounds are not easily oxidized at low temperatures. In other cases a selective utilization is shown. Such differences between the oxidations within and without the body emphasize the peculiar importance of the structural integrity—the cellular organization—of animals for these metabolic processes. The agencies by which the cells bring about these changes are as yet little understood. It seems probable, however, that the so-called unorganized ferments, or enzymes, are likely to assume an increasing prominence in the future study of the work of cells. Indeed, typical oxidative enzymes (oxidases) have already been found in many of the tissues.

The study of metabolism has for its object the investigation of the exchanges of material by which vital phenomena are produced, and the "conversion of chemical tension into living energy." The various processes concerned are by no means the same in all organs and tissues. The functions of the liver and of the salivary glands, for example, are distinct in many ways. Valuable data may be obtained by observation of the changes in isolated parts of the body. By maintaining an artificial circulation through "surviving" organs severed entirely or in part from their normal relations, the life of the cells may be continued for hours. Chemical analysis of the tissues under these circumstances may throw light on their metabolic processes; and changes in the composition of the circulating medium are likely to reveal the nutritive demands, the waste, or the specific elaborations of the cells. Again, by exclusion of individual organs their normal activity may be inferred from the absence of certain functions. The work of the spleen, the kidneys, the thyroids, has thus been elucidated by observations on individuals entirely or in part deprived of these organs. Finally, the changes in metabolism which accompany diverse pathological conditions of the body have also contributed to our knowledge of the subject. It is obvious that many difficulties attend the investigation of the metabolism of individual organs, although the problems involved are of great importance in physiology. Most of our knowledge of metabolism has come from a study of the organism as a whole. The intake (food and oxygen) and the output (excretions) have been ascertained under the most varied conditions, while the understanding of the intermediate processes is still largely a matter of "gaps and guesses." The body is constantly undergoing losses which must be made good sooner or later. New material must be contributed to replace the supply which has been exhausted. Some losses may be temporary, as in the secretion of milk, the production of eggs, the ejection of semen or menstrual flow. All of these are, however, relatively insignificant. Body substance is constantly being eliminated in other ways. The lungs give off carbon dioxide and water; through the kidneys, water, inorganic salts, and the nitrogenous compounds (urea, uric acid, hippuric acid, creatinin, etc.) of the urine are carried away; the skin eliminates water and inorganic salts together with insignificant traces of nitrogenous compounds (urea), epidermis formations, sebum, etc.; and with the fæces there passes out a mixture for the most part composed of residues of the digestive secretions, waste from the lining of the alimentary canal, indigestible materials, and (to a small extent only under normal conditions) undigested food residues. The following table compiled by Hammarsten indicates the average range of the quantities excreted in twenty-four hours by adult men living on a mixed diet.

TABLE A.

Water	2,500 to 3,500 gm.
Salts (with the urine)	20 " 30 "
Carbon dioxide	750 " 900 "
Urea	20 " 40 "
Other nitrogenous urinary constituents	2 " 5 "
Solids in the excrements	30 " 50 "

The relative importance of the various excretory channels may vary greatly according to external circumstances. Hammarsten has divided the loss in the following way: by the lungs, 32 per cent.; by the kidneys, 46–47 per cent.; by the skin, 17 per cent.; by the fæces, 5–9 per cent.

With the nature of the excreta and the channels by which they leave the body once established, it becomes possible to collect the output and quantitatively determine the component elements in order to compare them with the materials ingested. The make-up of various dietaries has been discussed elsewhere (see *Food*). The proteids, carbohydrates, and fats which are the main constituents contain the elements C, H, N, O, S, and P; other elements—Cl, Na, K, Mg, Ca, Si, F, Fe, I—occurring in very small amounts or merest traces only. The day of twenty-four hours is ordinarily taken as the unit period in experiments on metabolism in which the *balance of nutrition*—the relation between output and intake—is determined. The food and the solid and liquid excreta are readily analyzed by well-known chemical methods. For estimating the gaseous products—viz., the carbon dioxide and watery vapor given off and the oxygen consumed—special forms of apparatus have been devised. Respiration apparatuses for this purpose have been perfected by Regnault and Reiset, Pettenkofer and Voit and the Munich School, Hoppe-Seyler, Zuntz, Sondén and Tigerstedt, and Atwater and Rosa. For the details of construction of the various forms devised, the works referred to at the end of this article may be consulted. In general, the individual (man or animal) is confined within a large box or respiration chamber, through which a measured volume of air is constantly being passed. Portions of the air entering and leaving the chamber are analyzed, the CO_2 and the H_2O in particular being determined. The gain of these compounds in the air leaving the apparatus is directly attributable to the gases expired. The oxygen consumption is ordinarily ascertained by calculation, although in certain types of apparatus it can be estimated directly. In Zuntz's form the expired gases are collected directly from the mouth, respiration proceeding through an appropriate two-way valve while the nostrils are kept closed. Experiments of the latter sort can be carried on for short intervals only. On the other hand, the portability of the apparatus has made it possible to make observations under the most diverse conditions, such as mountain climbing, marching, bicycling, swimming, etc.

After this brief review of the methods ordinarily employed in the study of the total metabolism of the body, attention may be directed to the statistics of nutrition derived therefrom. It has been assumed by investigators that no essential differences exist in the main features of metabolism in the higher vertebrates; and many of the data obtained from observations on animals have been applied to man. So far as is known the chief end-products formed in the exchange of materials in all of these individuals are practically alike, carbon dioxide, water, and urea being of predominant importance. It by no means follows, however, that the details of the processes are the same in the different species. That the body cannot continue to undergo losses through the various excretory channels already described, without experiencing marked changes in its composition, is evident. The relationship between the incomings and outgoings—the *balance of matter*—may vary in different directions, a gain or loss resulting as the case may be. With a perfect balance maintained—*i.e.*, where no gain or loss in the weight of the animal body occurs—*nutritive equilibrium* is said to result. A determination of the balance of nitrogen and carbon permits the more important deductions regarding the metabolism of matter to be made. The following illustration (Table B) of the establishment of complete carbon and nitrogen equilibrium in a man of 70 kgm. living on a mixed diet is adapted from Ranke.

It is interesting to note how perfectly this nutritive equilibrium may be maintained for considerable periods

TABLE B.—BALANCE OF NUTRITION ON AN ADEQUATE DIET.

INCOME.			EXPENDITURE.		
Foods – Gm.	Nitrogen. Gm.	Carbon. Gm.	Excretions.	Nitrogen. Gm.	Carbon. Gm.
Proteid.......... 100	15.5	53	Urine	14.4	6.16
Fat.............. 100	....	79	Fæces	1.1	10.84
Carbohydrates... 250	....	93	Respiration (CO_2) .	....	208.00
	15.5	225		15.5	225.00

of time under suitable conditions of diet and work. The following balance-sheet is compiled from the numerous careful experiments of Atwater, Woods, and Benedict carried out under the direction of the United States Department of Agriculture. The first five experiments on a young man of 63.6 kgm. body weight show that he was very nearly in nitrogen and carbon equilibrium. No muscular work was performed. The last series of figures represents the average of nineteen rest and work experiments covering sixty-five days on different individuals.

TABLE C.—SUMMARY OF INCOME AND OUTGO OF NITROGEN AND CARBON IN MAN.

Duration. Days.	NITROGEN.				CARBON.				
	In food. Gm.	In fæces. Gm.	In urine. Gm.	Gain (+) or loss (−). Gm.	In food. Gm.	In fæces. Gm.	In urine. Gm.	In respiratory products. Gm.	Gain (+) or loss (−). Gm.
1.........	15.3	0.9	12.7	+ 1.7	234.3	6.9	8.7	220.9	− 2.2
1.........	15.3	.9	13.5	+ .9	234.3	6.9	9.9	215.3	+ 2.2
1.........	15.3	.9	13.6	+ .8	234.3	6.9	10.6	218.8	− 2
1.........	15.3	.9	13.7	+ .7	234.3	6.9	11.8	222.9	− 9.3
1.........	15.3	.9	15.2	− .8	234.3	6.9	13.6	221.7	− 7.9
Average.	15.3	.9	13.7	+ .7	234.3	6.9	10.9	219.9	+ 3.6
Average.	17.7	1.2	17.2	− 0.7	277.2	10.9	12.2	255.2	− 1.1

From the preceding it must not be inferred that nitrogen and carbon equilibrium always occur together. Conditions may arise readily where the income and outgo of nitrogen are exactly balanced, although there may be a simultaneous deficit or gain of carbon. This condition of the body is known as *nitrogenous equilibrium*, and is illustrated in the following table from Pettenkofer and Voit. The subject of the experiment was a man of 69.5 kgm. body weight.

TABLE D.—NITROGENOUS EQUILIBRIUM—MIXED DIET.

INCOME.			EXPENDITURE.			
Foods—Gm.	Nitrogen. Gm.	Carbon. Gm.	Excretions.	Nitrogen. Gm.	Carbon. Gm.	Water. Gm.
Proteid. ...... 137 Fat........... 117 Carbohydrates 352	19.5	315.5	Urine.........	17.4	12.7	1,279
			Fæces	2.1	14.5	83
			Respiration...	....	248.6	828
Water 2,016	....	....				
	19.5	315.5		19.5	275.8	2,190

A peculiar importance is attached to the study of the nitrogen output of the body owing to the fact that this element is derived entirely (or almost so under ordinary circumstances) from the decomposition of proteids. The output of nitrogen in the urine is practically a measure of the proteid katabolism of the body, although a part of the nitrogen of the fæces is due to such metabolic products as bile, intestinal secretion, etc. The quantities of nitrogenous material eliminated through loss of epithelial structures are ordinarily too small to possess any significance. Thus in man the daily loss of hair and nails is estimated at only 0.03 gm. N; for the waste epithelium the maximum of 0.5 gm. N has been assumed. Under ordinary circumstances the elimination of nitrogenous products in the sweat is very slight, although after profuse perspiration from 0.2 to 0.75 gm. N has been estimated in the excretion through the human skin. The average daily N output in the urine amounts to 16 gm. It has therefore usually been assumed in experimental work that no great error is involved by neglecting these small quantities of nitrogen in the excretory products other than the urine and fæces. The earlier assumption that gaseous nitrogen is eliminated through the skin and lungs has been shown to be entirely erroneous by the work of the Munich School, in which perfect nitrogenous equilibrium was established in the ways already described. Furthermore, repeated careful examinations of the expired air have shown that no nitrogen compounds other than the slightest traces of ammonia (NH_3) are ever present.

From the preceding considerations it is evident that the determination of the nitrogen balance of the body is of the highest value in any investigation of total metabolism. If the output of nitrogen in the urine and fæces is less than the intake with the food, it must be assumed that nitrogen is stored up in the body as proteid substance (protein). Likewise a loss of nitrogen beyond that of the ingesta must be attributed to a waste of tissue nitrogen compounds, the proteids. Since proteids contain an average of 16 per cent. of nitrogen, the quantity of proteid retained or lost may be estimated by multiplying the corresponding figure for N by the factor 6.25. For example, in one experiment a man received 19.1 gm. N in his diet, and during the corresponding day eliminated 16.5 gm. N in the urine and 1.5 gm. N in the fæces. The body thus retained $19.1 - (16.5 + 1.5) = 1.1$ gm. N, which are calculated as a gain of proteid material amounting to $1.1 \times 6.25 = 6.9$ gm.

A katabolism of proteid matter is constantly going on in the cells of the animal body. This is true in conditions of hunger where there is an unbalanced expenditure, as well as on an abundant diet. Proteid substance is essential to the structure of living protoplasm, the functions of which are intimately associated with the metabolism of this complex nitrogenous compound. The extent to which the body proteid breaks down varies within wide limits which will be discussed later. The most peculiar feature of proteid metabolism, however, lies in the fact that nitrogenous equilibrium may be maintained with variations of considerable magnitude in nitrogen import. With the proper nutritive condition of the body and an adequate supply of both proteid and non-proteid food, the nitrogen export tends to balance the import, even when large quantities are introduced. In other words, the organism endeavors to adapt its nitrogen output to the quantities of nitrogenous compounds taken in. What the exact nature of the proteid substances attacked is, has been a matter of dispute among physiologists. By some it is maintained that all proteid broken down has been an integral part of the living tissue cells; others, again, draw a distinction between this "morphotic" proteid and "circulating" proteid, the latter being independent of the structures themselves and forming the important antecedent of the nitrogenous katabolites. Discussion of the questions at issue would be unprofitable in this place. The observation of chief interest lies in the fact that beyond a certain point the animal body does not tend to accumulate proteid material. "Putting on flesh," in distinction from fattening, is a process difficult of accomplishment in a healthy adult. The explanation lies in the law of nitrogenous equilibrium; the tendency toward adaptation between proteid intake and nitrogenous metabolism. This is well illustrated in an experiment by von Noorden on a young woman.

TABLE E.—BALANCE SHEET WITH VARYING NITROGEN INTAKE.

Day.	Nitrogen intake. Gm.	Nitrogen in fæces. Gm.	Nitrogen in urine. Gm.	Balance. Gm.
1	14.4	0.70	13.6	+0.1
2	14.4	.70	13.8	− .1
3	14.4	.70	13.6	+ .1
4	20.96	.82	16.8	+3.34
5	20.96	.82	18.2	+1.94
6	20.96	.82	19.5	+ .68
7	20.96	.82	20.0	+ .14

That the carbon balance in metabolism does not necessarily follow the balance for nitrogen has already been indicated in the experiment on nitrogenous equilibrium quoted from Pettenkofer and Voit. The body may gain or lose in weight in spite of a perfect balance between nitrogen import and export. If, as in the experiment mentioned, carbon is retained, the question arises: In what form is it stored up? Carbon is a constituent of the proteids as well as of the fats and carbohydrates. If we assume that there is no gain or loss of carbohydrate, the gain of fat in this case is easily calculated. Ordinary body fats contain about 76 per cent. of carbon. Accordingly, by multiplying the carbon retained, $315.5 - 275.8 = 39.7$ gm., by the factor $\frac{100}{76} = 1.3$, the quantity of fat laid on, 52 gm., is ascertained. Let us next consider a case in which N equilibrium has not been attained, and gain or loss of proteid is determined. Part of the carbon goes with the nitrogen to form proteid, its relation being as 53 per cent. : 16 per cent., or 3.3 : 1. If, in case of loss of nitrogen and carbon, the quantity of the latter belonging to the nitrogen is calculated, any further deficit of carbon is inferred to be referable to fat lost and may be estimated as such. Similar considerations apply to the reverse case, and it is easy to ascertain whether excess of carbon in the food over the carbon of the excreta is stored up as proteid, or fat, or both.

There is another aspect of metabolism which deserves consideration here. The functions of the living animal organism are continued by the transformation of the potential energy of the foodstuffs or body constituents into kinetic energy. In this way mechanical work is done and heat is produced. The body has often been compared to a steam-engine in which similar energy transformations are accomplished. In the case under consideration the fuel is normally represented by the typical animal compounds: proteids, fats, and carbohydrates. The energy is liberated in part as a result of cleavage processes and more commonly through oxidative changes, the peculiarities of which have already been discussed. The efficiency of the body as a machine is relatively large. Under appropriate conditions as much as one-fifth of the available energy in the fuel (food) may be converted into mechanical work—a proportion seldom, if ever, equalled in machines of human construction. The remainder of the available supply is transformed into heat, by part of which the body temperature of the higher animals is kept up. Atwater and Rosa have determined the efficiency of a "man not accustomed to severe exercise who worked in this case eight hours a day on an ergometer, which consisted of a stationary bicycle belted to a small dynamo. The whole was placed in a respiration calorimeter (described below) in which the subject remained for several days. The total amount of heat given off was accurately measured by means of the calorimeter. The work done was determined by measuring the current produced by the dynamo. The electrical energy was then transformed into heat, and its amount was included in the total heat measured by the calorimeter. In addition to these heat measurements the total income and outgo of nitrogen, carbon, hydrogen, and water were determined. In these particular experiments the average work done was about 40 watts per day, or 109,000 kilogrammetres, equivalent to 256 calories per day. Dividing this by the total number of calories measured by the calorimeter, 3,726 per day, they obtain an average mechanical efficiency of 7 per cent. of the total energy metabolized. But after deducting the average amount of energy metabolized by the same man at rest, which had been found by several experiments to be about 2,500 calories, the remainder, which was assumed to be the energy metabolized for the performance of the work, is 1,226 calories per day, and the mechanical efficiency becomes, for these experiments, 21 per cent." Zuntz and others have reached the conclusion that about 35 per cent. of the extra energy of the food used in connection with the extra muscular work is available for that work; and from experiments on a bicycle rider (Miller) it has been calculated that during six days of almost continuous racing an efficiency of 36 per cent. was maintained. According to Carpenter the best record of any heat engine is probably that of the Deisal motor (33.7 per cent.). The best steam-engine record shows an efficiency of 22.7 per cent. Most engines developed in a form available for practical use are, however, decidedly inferior to these, as they are to the human machine.

Up to this point we have considered only the balance of matter in the body, by following the fate of the ingested foodstuffs in the chemical changes which they undergo. Equally important is the study of the *balance of energy*—a subject which still requires far more extensive investigation than has been accorded to it up to this time. The application of the law of the conservation of energy to the animal body has been accepted generally, although experimental confirmation was wanting until quite recently. If the law holds, the net income and outgo of energy should be the same. The methods by which this problem is attacked may next be considered briefly.

The total potential energy of the foodstuffs can be ascertained by determining the amount of heat which they yield on complete combustion. The results—heats of combustion—are conveniently expressed as heat units or *calories*, a small calorie being the amount of heat required to warm 1 c.c. of water from 0° to 1° C. The large calorie (kilocalorie), which is most commonly employed in this connection, represents the amount of heat necessary to raise 1 kgm. of water 1° C. The heats of combustion are determined in special forms of apparatus of which the special one devised by Berthelot and called "bomb calorimeter" is at present most widely used in various modifications. The details of the process must be consulted elsewhere. The heats of combustion of the foodstuffs may be taken as a measure of their potential energy and, with certain limitations, of their "fuel value," *i.e.*, their value for the production of heat and muscular work when they are consumed in the body. The fats and carbohydrates are completely burned up, with the formation of carbon dioxide and water. In the metabolism of proteids, however, the end-products, urea, uric acid, etc., represent products incompletely oxidized and thus still capable of yielding energy. The potential energy of these products must accordingly be subtracted from that of the total material from which they are formed in order to obtain the physiological fuel value of the proteids. The physiological value of each of the three classes of foodstuffs is given as average figures by Rubner:

1 gm. proteid	4.1 kilocalories
1 gm. fat	9.3 "
1 gm. carbohydrate	4.1 "

The consideration of nutrition with reference to the metabolism of energy has led to the discovery of an important physiological principle. It has been ascertained that the foodstuffs can replace each other in the body in proportion to the available potential energy contained in them, *i.e.*, according to their *isodynamic values*. For illustration, 100 gm. of proteid = 100 gm. of carbohydrate = 44.1 gm. of fat in combustion within the body, since each of these quantities will yield the same physiological fuel values, viz., 410 kilocalories. The experi-

mental verification of this principle was obtained by Rubner on animals as indicated below.

TABLE F.—ISODYNAMIC VALUES PER 100 PARTS OF FAT.

Nutrients, water free.	As determined by direct experiments with animals.	As determined by the calorimeter.	Differences in percentages.
Myosin	225	213	+ 5.6
Lean meat	243	235	+ 4.3
Starch	232	229	+ 1.3
Cane sugar	234	235	0
Grape sugar	256	255	0

The importance of the law of the isodynamic value of the foodstuffs lies in its application to dietetics; for the nutritive demands of the body are satisfied by the intake of potential energy. A certain minimum of proteid being excepted, it matters little how the remainder of the diet is constituted, *i.e.*, whether composed of fat, carbohydrate, or even proteid, provided that the total energy offered remains sufficient.

The outgo of energy in the body offers greater difficulties in its measurement. For the excreta this is estimated by direct calorimetric determinations (on the urine and fæces) which give a measure of the potential energy in them. The heat radiated from the body and the mechanical work done require special methods for their determination. The kinetic energy given off as heat is measured in a respiration calorimeter and accessory apparatus, the most successful forms of which have been devised by Rubner and Rosenthal in Germany and Atwater and Rosa in this country. The latter have carried their respiration calorimeter to a high degree of perfection. Its essential features are "a chamber seven feet long, four feet wide, and six and a half feet high, furnished with a folding chair, table and bed, and other appliances for physical comfort; apparatus for maintaining, measuring, and analyzing a ventilating current of air; arrangements for passing food and drink into the chamber and for removing the solid and liquid excreta; and devices for determining the heat given off from the body of the man in the chamber, and in work experiments, a stationary bicycle or other apparatus adapted for the performance of muscular work and for determining the heat equivalent of the muscular work done." (See article on *Calorimetry* in Vol. II.)

TABLE G.—COMPARISON OF INCOME AND OUTGO OF ENERGY IN EXPERIMENTS COVERING FIFTY-SEVEN EXPERIMENTAL DAYS—AMOUNTS PER DAY.

Kind of experiment.	Number of experimental days.	Net income (potential energy of material oxidized in body).	Net outgo (kinetic energy given off from body).	Difference (in terms of net income).	
		Calories.	Calories.	Calories.	Per cent.
Average for 11 rest experiments	37	22.34	22.30	– 4	– 0.2
Average for 6 work experiments	20	36.74	36.56	– 18	– .5
Average for 17 rest and work experiments	57	27.40	27.31	– 9	– .3

In calorimetric investigations on dogs, Rubner found that differences of income and outgo of energy in the individual experiments were in some cases quite appreciable, but for the forty-five days covered by the experiments there was a discrepancy of only 0.47 per cent. These observations have thus splendidly confirmed the application of the law of the conservation of energy to the living animal body. No less striking and conclusive are the results obtained on man by Atwater and his associates working with the respiration calorimeter just described. Since irregularities in the physiological processes are unavoidable, variations in the individual experiments are inevitable. The errors, however, tend to counterbalance one another in a series of experiments, as Table G shows.

The averages for the fifty-seven days of the seventeen experiments show a difference of 0.3 per cent., a quantity far within the limits of experimental error and physiological uncertainties. No more striking demonstration could be expected. It is instructive to compare the amounts of heat given off in different ways in the same experiments.

TABLE H.—PERCENTAGES OF TOTAL ENERGY GIVEN OFF FROM THE BODY IN DIFFERENT WAYS.

Heat.	In rest experiments. Per cent.	In work experiments. Per cent.
From the skin by radiation and conduction (and in exhaled air)	74.2	62.3
In urine and fæces	1.4	.5
In water vaporized from lungs and skin.	24.4	30.8
Heat equivalent of external muscular work done	....	6.4
Total	100.0	100.0

Nutritive equilibrium is an essential condition for the integrity of the body and the unimpaired continuation of its functions. The factors which occasion a demand for nutritive material are growth, tissue repair, work, and maintenance of body temperature. In the healthy adult the last two are the chief factors to be dealt with. Otherwise stated, the organism calls for potential energy in the form of available food; and the extent of the needs of the animal must vary with a variety of conditions. During complete rest of the body a transformation of energy is occasioned by the work of the heart and respiratory mechanism, the digestive glands and accessory apparatus, accidental muscular movements, etc.; but the chief demand comes from the great mass of living cells which are the seat of continual chemical change. Hence it follows that a large aggregate of these cells, as exemplified in a large individual, will require more food than a smaller one. If we compare two individuals of equal weight one of whom is relatively corpulent (*i.e.*, contains a larger proportion of physiologically inert fat), it will be found that the extent of metabolism here likewise depends on the total mass of active tissue. These facts are made evident by a study of the energy transformation, or the extent of metabolism in individuals of various sizes when at rest, and likewise by a study of the oxygen consumption which occurs under these circumstances. Thus in an experiment of Pettenkofer and Voit a muscular man of 71 kgm. metabolized 78 gm. of proteid and 215 gm. of fat during rest and fasting, while a less vigorous individual of 59 kgm. required only 63 gm. of proteid and 162 gm. of fat. Again, a corpulent individual of 73.6 kgm. (at rest and fasting) utilized 2,136 calories = 29 calories per kilogram in twenty-four hours, while a strong man of equal body weight (71.1 kgm.) required 2,392 calories = 33.6 calories per kilogram. The conditions of experiment being alike here, we must attribute the variations to the absolute preponderance of active cells in the second individual. Zuntz has calculated that the circulatory mechanism requires from 3 to 10 per cent. and the work of respiration from 10 to 20 per cent. of the total potential energy lost during rest of the body as a whole.

It is thus evident that the great bulk of the potential energy which an individual at rest transforms is converted into heat rather than external work. Heat production, *i.e.*, utilization of potential energy in the animal body, is regulated according to the loss of heat which it experiences. This has been emphasized by the extensive investigations of Rubner. Other factors may add to the effect in a minor degree, but in the absence of muscular work it is the tendency toward the lowering of body temperature which plays the important rôle in regulating

heat production. Physiologists have long known that in proportion to their body weight small individuals give off more heat (and accordingly undergo more active metabolism) during rest than larger ones under similar external conditions; and this observation applies with restrictions to animals of different, as well as to those of the same, species. Smaller animals have, as both Richet and Rubner pointed out, a proportionately larger body surface than larger ones. A large surface exposure facilitates loss of heat, which in turn stimulates metabolism and heat production. Numerous experiments have confirmed the fact that heat radiation from the body and katabolic changes are proportional to the extent of surface and not to the mass of the animal. This is shown in the following table in which the intensity of heat production was calculated by Rubner from the quantity of proteid and fat consumed by seven dogs of different sizes:

TABLE I.—RELATION OF HEAT PRODUCTION TO SIZE OF BODY.

Weight of animal. Kgm.	Body surface. Sq. cm.	Body surface per kgm. of body weight. Sq. cm.	Daily heat production per kgm. of body weight. Calories.	Heat-production per square metre of body surface. Calories.
31.20	10,750	344	35.68	1,036
24.00	8,805	366	40.91	1,112
19.80	7,500	379	45.87	1,207
18.20	7,662	421	46.20	1,097
9.61	5,286	550	65.16	1,183
6.50	3,724	573	66.07	1,153
3.19	2,423	726	88.07	1,212

Since heat is produced by the physiological combustion of body compounds, and since the normal temperature of animals of the same species is approximately constant, it is to be expected that the products of these oxidations, such as carbon dioxide, should likewise vary inversely with the weights of the animals. The output of carbon dioxide per unit of body surface, however, is very constant, as the following observations of Richet on dogs show:

TABLE J.—THE PRODUCTION OF CO_2 IN RELATION TO THE SIZE OF THE BODY.

Weight of animal—Kgm.	CO_2 per kgm. and per hour.	CO_2 per sq. dcm. and per hour.
26	0.925	0.250
24	.940	.244
20	.970	.236
16	1.200	.270
14	1.045	.228
12	1.120	.229
10	1.200	.233
8	1.300	.233
6	1.400	.227
5	1.550	.242
4	1.750	.245

The relation of body surface to heat production applies equally to the human individual at various stages of its growth. Rubner has constructed the following table showing the heat production in calories per twenty-four hours.

TABLE K.—HEAT PRODUCTION IN MAN (TWENTY-FOUR HOURS.)

Subject.	Total calories.	Calories per kgm.	Calculated body surface in cm^2.	Total calories per m^2 of body surface.
Child of 4.03 kgm.	368	91.3	3,013	1,221
" 11.8 "	966	81.5	7,191	1,343
" 16.4 "	1,213	73.9	7,681	1,579
" 23.7 "	1,411	59.5	10,156	1,389
" 30.9 "	1,784	57.7	12,122	1,472
" 40.4 "	2,106	52.1	14,491	1,452
Man of 67 "	2,843	42.4	20,305	1,399

Here too the heat production per kilogram is seen to be larger in the smaller body. The relatively smaller metabolism per unit of surface in the infant is presumably due to a more perfect conservation of heat through artificial conditions at this period of life. The somewhat larger figures for the next period are perhaps attributable to the higher "nutritive plane" or greater protoplasmic activity in early youth.

The power of rapidly increasing heat production to meet a sudden demand is far more important to a small animal than to a large one. As Stewart has expressed it, to reduce the temperature of an elephant or of a horse by one degree, a considerable quantity of heat must be lost, while a very slight loss would suffice to cool a mouse by that amount. The surface by which the heat is lost is, furthermore, greater in proportion to the mass in small than in large animals. Accordingly, the fact that the metabolism of an animal varies approximately as its surface, and not as its mass, is an illustration of the nice adjustment by which heat equilibrium is maintained. This chemical activity is regulated by the nervous system; for Richet has shown that anæsthetized animals no longer retain this regulation. For example, in dogs to which chloral was administered, the average results obtained for the carbon dioxide output no longer showed the typical increase with decrease of weight that was indicated in a previous table for normal fasting dogs at rest.

TABLE L.—METABOLISM IN CHLORALIZED ANIMALS.

Average weight of dog. Kgm.	CO_2 output per kgm. and per hour. Gm.	Average weight of dog. Kgm.	CO_2 output per kgm. and per hour. Gm.
28.5	0.550	7.75	0.643
13	.597	4.5	.609

In the preceding paragraphs the characteristics of total metabolism in the fasting organism at rest have been discussed. The ingestion of food is of itself sufficient to modify metabolism, as shown by the increased production of heat and of carbon dioxide, and likewise by the increased consumption of oxygen as compared with the hunger figures. The increase is slight compared with that occasioned by other causes, such as work, and is unquestionably attributable to activity of the digestive glands and the muscular apparatus of the alimentary tract. The greatest augmentation of heat production usually occurs soon—as early as the first hour—after feeding, *i.e.*, at a period when digestion (rather than absorption) is at its height (Reichert). Similar increase of metabolism can be instigated in the absence of food by agents, such as purgatives, which provoke the gastro-intestinal canal to activity; while it fails to appear when food material is introduced directly into the circulation, without being subjected to digestive processes in the body. Furthermore, both Rubner and Reichert have demonstrated that the extent of metabolism varies with the kind of food ingested. Thus after proteid feeding the effects are more marked than after fat feeding. These facts all serve to indicate that ingestion of food directly increases the oxidative processes in the body because of the consequent work of the digestive apparatus, and not necessarily because the food ingested is at once burned up. A slight rise of body temperature which Reichert and others have shown to be due to heat production, and which is sometimes referred to as "digestive fever," is observed during the period of digestion. Zuntz has calculated that the "digestion work" in a man at rest may increase metabolism and heat production ten per cent.; while in an individual at work, *i.e.*, already subject to increased oxidative processes, it may amount to only five per cent. The extent of immediate utilization of the remainder of the ingesta depends on factors which are yet to be considered. Of these muscular work is normally the most prominent. Experimental observation at once reveals the vast influence which work has on metabolism. In general, the increased heat production, elimi-

nation of carbon dioxide and water, and the heightened consumption of oxygen bear witness to the source of the energy set free. A few figures from actual experiments will best illustrate this statement. Thus the following table compiled from the determinations of Atwater and Benedict on healthy men indicate the increased metabolic activity incidental to work as shown by the increased output of carbon dioxide. Some details of the changes brought about will be considered later, in particular the nature of the body constituent burned up.

TABLE M.—CARBON DIOXIDE ELIMINATED BY LUNGS AND SKIN DURING REST AND WORK.

Kind of experiment.	Days covered by experiments.	Total amount in twenty-four hours. Grams.	Rate Per Hour. Day Periods. 7 A.M. to 1 P.M. Grams.	Rate Per Hour. Day Periods. 1 P.M. to 7 P.M. Grams.	Rate Per Hour. Night Periods. 7 P.M. to 1 A.M. Grams.	Rate Per Hour. Night Periods. 1 A.M. to 7 A.M. Grams.	Average for twenty-four hours. Grams.	Proportion of Total for Twenty-Four Hours. Day Periods. 7 A.M. to 1 P.M. Per cent.	Proportion of Total for Twenty-Four Hours. Day Periods. 1 P.M. to 7 P.M. Per cent.	Proportion of Total for Twenty-Four Hours. Night Periods. 7 P.M. to 1 A.M. Per cent.	Proportion of Total for Twenty-Four Hours. Night Periods. 1 A.M. to 7 A.M. Per cent.
Rest	45	794	37.8	37.2	35.0	22.4	33.1	28.6	28.1	26.4	16.9
Work	20	1,253	75.5	76.6	34.1	22.6	52.2	36.2	36.7	16.3	10.8

The elimination of carbon dioxide during the working hours is twice as large as during the corresponding hours of the rest days. In these experiments the heat equivalent of the external muscular work done was only 6.4 per cent. of the total energy given off from the body in different ways.

The following data, taken from experiments on man by Katzenstein, show the intensity of the metabolic changes which work brings about, as expressed in the consumption of oxygen per minute in contrast with the conditions prevailing during rest: During rest, 263 c.c.; walking on level, 763 c.c.; walking uphill, 1,253 c.c.

Rubner has calculated the total metabolism of a large number of individuals on the basis of an average body weight, and expressed in heat units (kilocalories), thus:

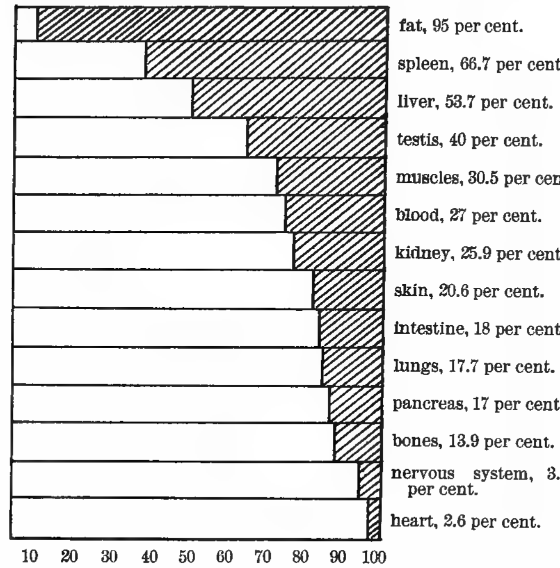
TABLE N.

During rest	2,303 cal.	= 32.9 cal. per kilo.	
Slight bodily work (physicians, etc.)	2,442 "	= 34.9 " "	= 6% increase.
Medium bodily work (soldiers, etc)	2,868 "	= 41.0 " "	= 24% "
Severe work (machinists, etc.)	3,362 "	= 48.0 " "	= 45% "
Exhausting work (miners, etc.)	4,790 "	= 68.4 " "	= 108% "

Finally, the important influence of training must be noted in this connection. It has repeatedly been shown that the trained individual works more economically, *i.e.*, utilizes less potential energy in accomplishing the same muscular task. No specific effects attributable to mental activity or to sleep have yet been detected. The slightly diminished metabolism during sleep is usually ascribed to the absence of all muscular effort.

In considering the influence which the various constituents of the diet exert upon metabolism, it may be well to take up first the changes which go on in the absence of food, *i.e.*, in *starvation* or inanition. Certain species are adapted by nature to undergo prolonged hunger without serious harm. This is true of hibernating animals, such as the marmot and the bear, in which the vital processes are at an ebb during certain portions of the year. In most animals, however, katabolism continues uninterruptedly during starvation. The body consumes its own tissues, and the extent of the changes will depend somewhat upon the previous nutritive condition of the individual. The store of fat is the first to be called on, and the relative participation of the various organs and tissues is shown graphically in the chart constructed from Voit's analyses of starved animals.

TABLE O.—GRAPHIC REPRESENTATION OF THE PERCENTAGE OF TISSUES LOST DURING STARVATION. THE SHADED AREAS REPRESENT LOSS, THE UNSHADED AREAS RESIDUE AT DEATH. (From Waller.)



An inspection of the diagram above brings to light the significant fact that those organs, viz., the heart and central nervous system, which serve the body in most important capacities are not drawn upon until the very end. Thus they work at the expense of the other tissues. During starvation urea continues to be excreted in the urine, the quantity being rather large for a day or two and then reaching a daily level which may remain fairly constant for some time. This level, it may reasonably be assumed, represents the extent of proteid katabolism necessary for the continuance of the bodily functions. Where there is an abundance of body fat, the nitrogen output may remain at a low figure for some time. The sudden rise in urea excretion before death intervenes has been interpreted to indicate that the fat has largely been used up and that tissue proteids are thenceforth called upon to yield the entire energy liberated. Some of the experiments on fasting men who were previously well nourished indicate a low nitrogen output, as low as 3.2 gm. per day being obtained by Luciani at the end of Succi's thirty days' fast. In other cases a somewhat larger output has been found. Thus in careful experiments by Zuntz, I. Munk, and others in Berlin on the "professional faster" Cetti and on Breithaupt, the data following were obtained from examination of the urine. The nitrogen has been calculated to proteid (N × 6.25).

TABLE P.

Day.	Cetti. Nitrogen output. Grams.	Cetti. Equivalent in Proteids. Grams.	Breithaupt. Nitrogen output. Grams.	Breithaupt. Equivalent in proteid. Grams.
Before fasting	13.49	84.9	13.02	82.0
First hunger day	13.545	85.3	10.01	63.1
Second hunger day	12.586	79.3	9.92	62.5
Third hunger day	13.121	82.7	13.29	83.7
Fourth hunger day	12.393	78.1	12.78	80.5
Fifth hunger day	10.695	67.4	10.95	68.9
Sixth hunger day	10.100	63.6	9.98	62.2
Seventh hunger day	10.855	68.6		
Eighth hunger day........	8.903	56.1		
Ninth hunger day	10.833	68.2		
Tenth hunger day........	9.467	50.7		
First eating day	13.35	84.1	11.88	74.7

Of the total loss of body weight during inanition, about two-thirds may be ascribed to loss of water, and the remaining one-third to body proteid and fat, the relative proportion of the latter being determined by the previous nutritive condition. It is therefore obvious that complete inanition is more far-reaching in its effects and less readily endured than starvation in which water is consumed. During hunger the fæces which continue to be passed from the intestine have their origin in materials poured into the alimentary canal. In appearance the "hunger fæces" resemble those following a diet rich in meat; and the thought is at once suggested that the fæces ordinarily discharged after an easily digestible diet consist, principally, of secretory products from the alimentary tract, and are not to be considered as the undigested residue of the food to any great extent. In the experiments on Cetti and Breithaupt quoted above, the average daily quantity of dry substance in the fæces was 3.8 and 2 gm. respectively, having a nitrogen content of from five to eight per cent. Normal fæces ordinarily contain from three to four per cent. of nitrogen.

To the physician the study of metabolism in hunger is of interest in connection with the observations made in various conditions of deficient nutrition, or malnutrition. In many of these cases the proteid metabolism may fall to a very low limit, especially where the contributory causes are gradual in their onset and where, as in paralysis, there is little bodily movement to call upon the store of energy.

It will be impossible, within the brief limits of this article, to discuss in detail the influences which the various factors of the diet exert on metabolism, and on proteid metabolism in particular. The dogmatic statements which may be made must be accepted with some reserve, since a vast number of modifying conditions must be taken into consideration in each case. The tendency toward the establishment of *nitrogenous equilibrium* has already been referred to. Briefly it may be expressed as follows: On a diet sufficient to cover the calorimetric needs of the body, the extent of nitrogenous (proteid) metabolism is determined within certain wide limits by the intake of nitrogenous food. For the lower limit about 0.5 gm. of proteid per kilogram of body weight may be accepted, a normal figure (Voit's) being 1.5 gm. per kilogram. These figures are exclusive of the losses through the fæces. The latter will vary somewhat with the nature of the diet, certain forms of vegetable proteid being utilized less readily than the proteids of meat. The differences are, however, merely due to differences in the digestibility and absorption of the two classes of materials, occasioned by the character of the vegetable foods with their cellulose structures. So far as is known at present, the pure vegetable proteids undergo changes in metabolism directly comparable with those ascertained for the proteids of animal origin.

In man nitrogenous equilibrium can be attained for a short time on a purely proteid (meat) diet. The large quantity of such food which is necessary is eaten and digested only with great difficulty. The process of "putting on flesh" in distinction from "laying on fat" is accordingly confined to a few general conditions of nutrition. These include the periods of growth and of convalescence after wasting disease or deficient nutrition. The determining factor in any case is the immediate nutritive state of the tissue cells; and thus in part is explained the hypertrophic growth of muscles incidental to increased activity. The condition of the cell rather than the character of the food material is perhaps the important element here. Undoubtedly variations occur with the species as with the individual in this respect; and Pflüger has pointed out cases in which the growth of the total cell substance may be assumed to be doubled after proteid feeding. A most peculiar fact is the marked increase in proteid metabolism and in total metabolism brought about by increasing the proteid of the diet. This is indicated in the following table constructed by Tigerstedt from the experimental data of Pettenkofer and Voit.

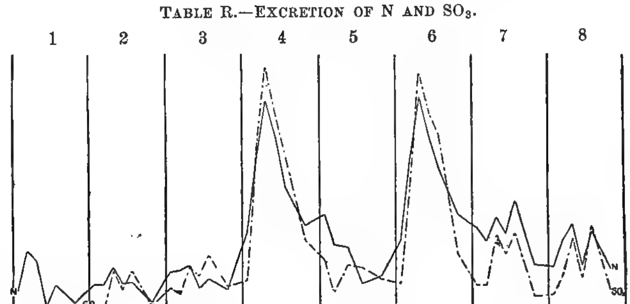
TABLE Q.—EFFECT OF PROTEID DIET ON METABOLISM.

Number of the experiment.	Nitrogen Intake. Grams.	Nitrogen output. Grams.	Gain (+) or loss (−) of fat. Grams.	Total metabolism (heat production). Kilocalories.
1	0	5.61	− 98	1,067
2	17	20.37	− 61	1,106
3	34	36.69	− 43	1,360
4	51	51.00	− 24	1,552
5	61	59.74	− 36	1,893
6	68	69.50	+ 8	1,741
7	85	85.41	+ 4	2,181

The calculation of the total metabolism in units of heat produced in No. 7 gives results twice as large as those obtained during hunger (No. 1), while the proteid metabolism undergoes a manifold stimulation. Upon such facts depends the efficiency of some of the prevalent modes of treatment for obesity. The large proportion of proteid in the diets prescribed provokes a relatively large waste of tissue substance, especially when the total intake is comparatively small for the daily needs.

The sulphur and phosphorus of the proteids, oxidized in metabolism to sulphuric acid and phosphoric acid, are excreted as salts in the urine. Their elimination usually runs closely parallel to that of nitrogen, the quantity of sulphates taken in with the diet being very small. The determination of the sulphates of the urine affords a valuable means of controlling experiments on proteid metabolism, especially where non-proteid nitrogenous substances (such as amido-acids) are ingested. The diagram presented below shows the relative fluctuations in the average rates of excretion of N and SO_3 in the experiments of Sherman and Hawk on men living on a fixed diet. The estimations were made at intervals during the day, and the values on the left represent percentages of an assumed standard rate of excretion for each of the constituents. The parallel vertical lines separate the successive days. On the fourth and sixth days large additional quantities of proteid were consumed. It will be seen that in general the excretion of sulphates ran quite parallel to that of nitrogen.

TABLE R.—EXCRETION OF N AND SO_3.



The phosphoric acid of the urine represents one of the end-products of the katabolism of nucleoproteids, and an increased elimination of it may be interpreted as evidence of nuclear waste in the body, if no nucleic acid compounds (such as occur abundantly in thymus, pancreas, etc.) or phosphorized proteids (pseudonucleins) like casein are ingested. Conditions may arise in which the exact parallelism between N and P excretion is abolished. Röhmann and his pupils have shown that these phosphorized proteids have a peculiar importance in nutrition, and that phosphorus in the form of inorganic phosphates cannot completely replace such organic com-

pounds of phosphorus as are represented by casein and vitellin.

We have seen that the body may soon reach nitrogen equilibrium after ingestion of considerable quantities of proteid. The study of the time within which the extra nitrogen is again eliminated has indicated that the proteid is quickly broken down in metabolism. A glance at the diagram of N and SO_3 excretion presented above verifies this. When lean beef sufficient to furnish about 64 gm. of extra proteid was taken with breakfast on the two days indicated, the nitrogen of the urine began to rise in the first three hours and reached a maximum between the sixth and ninth hours, after which it declined at first rapidly and then more slowly, reaching its normal after about thirty-six to thirty-nine hours. The nature and extent of the changes in the urine seem to have been about the same when the proteid was simply added to the diet as when it was substituted for an isodynamic amount of fat.

A consideration of the influence of the non-nitrogenous foodstuffs, the fats and carbohydrates, leads to conclusions quite different from those drawn for the proteids. It is evident that the non-nitrogenous foods cannot be fed alone for any length of time without bringing about effects comparable with those obtained during hunger. The chief interest regarding their behavior in metabolism therefore lies in the influence which they exert on nitrogenous or proteid katabolism. In general, it may be stated that the fats and carbohydrates, even when fed in large quantities, fail to increase metabolism in any such degree as does proteid feeding. On the contrary, the presence of non-nitrogenous constituents in the diet tends to diminish the amount of proteid required to bring the body into nitrogenous equilibrium. The fats and carbohydrates, and the so-called "carbon moiety" of the proteids, *i.e.*, the portion remaining after the deduction of sufficient carbon to unite with the nitrogen to form urea, may all be deposited in the organism in the form of fat or glycogen. Or, again, by being burned up they may protect the tissue fat from katabolism and in this case likewise bring about a diminished loss or resultant gain to the body. This is known as *proteid-sparing* action. The adipose tissue of the body may apparently act in a manner analogous to that of the fat of the diet. It is generally admitted that the proteid-sparing power of carbohydrate food is distinctly greater than that of the fats. Indeed a quantity of proteid which fails to produce nitrogen equilibrium may do so when carbohydrate is added to the diet. The same is true to a lesser degree in the case of fats. Thus a dog which required 1 kgm. of meat to reach N equilibrium was observed to show a similar nitrogen balance on a diet of only 500–600 gm. of meat together with 100–150 gm. of fat. The extent of fat utilization, on the other hand, will depend on the quantities of proteid and carbohydrate simultaneously fed, and also on the amount of muscular work performed. From an economic standpoint the sparing action of the carbohydrates on proteid katabolism is of interest in view of the relative cheapness of this type of foodstuff in comparison with proteids and fats. Problems of cost as well as of efficiency must enter largely into practical dietetics, especially where the nutrition of large masses is involved. The proteid-sparing action of carbohydrates is well illustrated by the figures compiled from an experiment by I. Munk on a dog of 28 kgm. (see Table S).

No consideration of the influence of the various dietary constituents would be complete without reference to a number of accessory substances either commonly taken with the food or closely related to the foodstuffs proper. Thus the albuminoid *gelatin* enters into ordinary diet to a considerable extent. Although it contains nitrogen in practically the same proportions as this element exists in the simple proteids, gelatin cannot completely replace the latter. Experiments on animals have shown that when gelatin is fed exclusively, tissue proteids are always consumed in excess of the gelatin introduced and sooner or later serious symptoms intervene. For example, a 50 kgm. dog living on 200 gm. of gelatin, 250 gm.

TABLE S.—EFFECT OF CARBOHYDRATES ON PROTEID METABOLISM.

Food.		Flesh.	
Meat. Grams.	Carbohydrates. Grams.	Metabolized. Grams.	Gain (+) or loss (−). Grams.
200	250	263	− 63
200	300	223	− 23
200	500	201	− 1
200	500	172	+ 28
200	500	132	+ 68
200	500	168	+ 32
200	500	122	+ 78

of starch, 100 gm. of fat, and 12 gm. of beef extract per diem died in thirty days as a result of continued proteid katabolism (I. Munk). Ingested with proteid and other foodstuffs, however, gelatin exerts a noticeable proteid- and fat-sparing action and thus behaves like a non-nitrogenous food. It has been found possible to replace as much as five-sixths of the proteid of the diet with gelatin without unfavorable outcome.

In view of the peptonization which proteids undergo in the digestive processes it has been asked whether the various hydration products, *albumoses* and *peptones* in particular, can replace ordinary proteids. A practical aspect of the problem is seen in the present widespread use of predigested or partially digested foods. From the data available the statement seems justifiable that some of these may replace proteid without disturbance of the nitrogenous equilibrium of the individual. Recent investigation has indicated that distinct differences occur in various digestive products, and as yet no experiments in this direction have been sufficiently prolonged to permit any far-reaching statements. Whether the non-proteid nitrogenous compounds (such as *asparagin* and *amido acids*) can undergo a synthesis to proteid—as Loewi has recently suggested (1902)—remains to be seen. *Fatty acids* have been observed to exert the same proteid-sparing action as comparable quantities of fat. The physiological action of *alcohol* has formed the subject of much controversy. It seems certain, however, that moderate quantities are almost completely oxidized, and in non-toxic doses probably may exert a slight proteid-sparing action. The function of the *inorganic salts* of the diet is apparently exerted more in directing the metabolism of the body than in any immediate participation in the exchange of materials. Their importance is fully demonstrated by the serious effects which follow the removal of even single elements from the diet. At certain periods Ca, Fe, etc., enter into synthetic processes. Large quantities of common tissue constituents, such as chlorides and phosphates, tend in general to exert an increased action on the metabolism of proteids.

The general features of metabolism during muscular activity have already been reviewed. There can be little question that the muscles themselves are the seat of active chemical change. It is sufficient to point to the disappearance of glycogen from the contracting muscle and the appearance of products like carbon dioxide and lactic acid. The lymph bathing the muscle cells is called upon to furnish oxygen and organic compounds, while it carries away the products of katabolism. We are now in a position to consider what are the sources of the energy expended. Are the nitrogenous or non-nitrogenous constituents drawn upon in muscular work? The older view of Liebig that the muscles work entirely at the expense of their proteid constituents was conclusively overthrown by the investigations of Voit and his successors. The output of carbon dioxide and water is promptly increased by muscular activity to an extent directly proportional to the work done. With reference to nitrogenous metabolism no such effect can be noted. Under satisfactory conditions of diet the elimination of urea is scarcely, if any, greater during work than with the same intake of proteid during rest. This indicates clearly that the non-nitrogenous compounds are the chief

sources of the energy expended by the muscles. Many statistical facts are in harmony with this. Thus the diet of the laboring classes compared with that of less active persons does not contain an excess of proteid sufficient to account for more than a small fraction of the extra work done and heat produced, as will be seen in the commonly accepted standards below.

TABLE T.—COMPARISON OF DIETARY STANDARDS.

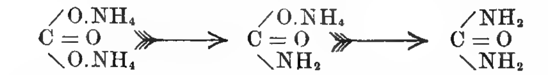
Subject.	Proteids. Grams.	Fats. Grams.	Carbohydrates. Grams.	Potential energy. Kilocal.
Man at moderate work (Voit)	118	56	500	3,055
Man at moderate work (Atwater)	125	....	....	3,500
Man at hard work (Voit)	145	100	450	3,370
Man at hard work (Atwater)	150	....	....	4,500

Actual metabolism experiments are in accord with what the statistical inquiry would lead us to expect. On an abundant mixed diet no marked increase in proteid katabolism attends periods of muscular work. When, however, the diet is too scanty to furnish the potential energy required, body proteid may be called upon to furnish the deficiency; and under these circumstances the nitrogen output in the urine is observed to be increased. The same phenomenon is observed after prolonged or severe exertion, although the extra nitrogen output may not occur until the day following the exercise. This suggests (as experience in training athletes shows) that the increased cellular activity of the muscles calls forth metabolic changes in the contractile tissue independently of the transformation of energy incidental to the work done. Pflüger has lately attempted to refer the source of muscular energy to proteid substances, since he succeeded in keeping a dog for weeks upon a diet of very lean meat and causing him to do a very large amount of muscular work during this period. Experiments of this sort merely show that in the absence of non-nitrogenous food the body can utilize proteid in liberating energy through the muscles. This is the less remarkable since recent investigation has made probable the existence of large carbohydrate groups in many of the proteids. As Schaefer has said in this connection: "The most probable view appears to be that the muscle, like other cells, although it can only build up the bioplasm out of proteid, is nevertheless able to produce muscular energy by the oxidation of any or all the organic foodstuffs, and that this process is attended only by such small disintegration and loss of the proteid material of the bioplasm as is necessarily attendant upon its functional activity—a loss which is comparable to the wear and tear of the working parts of the machine as distinct from its consumption of fuel."

Of other influences which may bear upon metabolism nervous excitement or *mental activity* apparently brings about no noticeable change in the katabolism of proteid or the utilization of fat. In the higher animals which maintain an approximately constant body temperature, changes in the surrounding temperature do not modify proteid metabolism. With increased *cold* more fat is used up by the organism. The influences of *age* and *sex* are largely dependent upon variations in the size of the body which condition the inequalities in heat regulation already discussed. In old age metabolism is less intense and the nutritive requirements are consequently diminished. The few experimental data at hand indicate that during the period of menstruation the output of nitrogenous waste may be diminished. A similar sparing of proteid appears to occur during the period of gestation. Many *drugs* exert pronounced effects on metabolism either directly or indirectly through the physiological reactions (such as muscular excitability, or sleep) which they provoke. Coffee and tea, and some of the more widely used food preservatives (borax, formaldehyde, etc.) have no extensive effects in this respect, when used in very small quantities. In larger doses they tend to increase proteid metabolism. The action of various therapeutic agents cannot be discussed here.

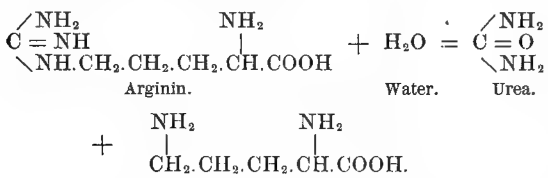
No account of metabolism in disease need be given in detail here, since the peculiar features are presented elsewhere under the descriptions of the various pathological states (see *Diabetes*, *Fever*, etc.). In *febrile diseases* it seems to be demonstrated that katabolism is stimulated and may be increased twenty-five per cent. beyond that which occurs in health. The extensive exchange of materials is usually associated with increased work of the heart and respiratory mechanism. To this may be added the results of the deficient nutrition which is common to the sick, and a specific effect of the toxic bacterial or protoplasmic products which may directly stimulate proteid metabolism. The destruction of the nitrogenous tissue compounds may proceed very rapidly in fever and lead to extreme emaciation, although total metabolism may not be more marked. In *diabetes* increased proteid katabolism usually occurs. It seems likely that this is a physiological consequence of the failure on the part of the organism to utilize carbohydrates; and in many of the milder types the loss of nitrogenous substance may be limited by an appropriate diet which will afford sufficient energy in place of the wasted sugar. The extensive proteid katabolism in the several forms of diabetes must, however, be attributed to toxic effects and to the perversions of metabolism peculiar to the disease. The effects of *hepatic disease* vary with the nature of the pathological condition. In icterus they are largely indirect, depending in part on the remote results of impaired digestion, while in cirrhosis and in acute atrophy of the liver we have to deal with inefficient hepatic cells. Thus it is that unusual end-products of proteid decomposition (such as leucin and tyrosin) make their appearance in the urine, and direct attention to the incompleteness of the chemical reactions in the cells which are ordinarily entrusted with important functions. In certain types of *leukæmia* there is evidence of disordered metabolism of the nuclein substances, giving evidence of itself in an increased output of uric acid and phosphates in the urine. In various forms of *anæmia* the peculiar perversion of metabolism consists in disturbances of internal respiration connected with the deficiency of blood pigment. Further disturbances of nutrition may be secondary. The metabolic phenomena in diseases of the *gastro-intestinal tract* are largely the outcome of malnutrition, the deficient work of the digestive mechanism perhaps being accompanied in some instances by an autointoxication. The whole subject of metabolism in disease deserves further study before more general conclusions can be drawn.

The history of the foodstuffs after their introduction into the organism is fragmentary and uncertain in many details. The formation of *urea*, $C{=}O\begin{smallmatrix}/NH_2\\ \backslash NH_2\end{smallmatrix}$, the most important nitrogenous end-product of the katabolism of simple proteids, can safely be assigned to the liver; although evidence is not wanting that small quantities may arise elsewhere, perhaps in the muscles. The nature of the intermediate steps still remains somewhat hypothetical. There is much in favor of the view that the proteid is first transformed to simple compounds like ammonia (NH_3) and carbon dioxide (CO_2), and that ammonium carbonate $(NH_4)_2CO_3$ may be the precursor of urea. It is not unlikely that the bulk of the proteid nitrogen leaves the various organs in the form of ammonium lactate, $C_2H_4(OH)COO.NH_4$, which is brought to the liver and there oxidized to carbonate. When the liver cells undergo degeneration, the amount of urea in the urine is diminished while the quantity of ammonium compounds is augmented. Furthermore, urea can be formed in the liver from ammonium carbonate, other ammonium salts, and even amido acids such as glycocoll, $CH_2(NH_2)COOH$. Drechsel assumed that the process took place with the formation of ammonium carbamate as an intermediate stage, as follows:



Ammonium carbonate. Ammonium carbamate. Urea.

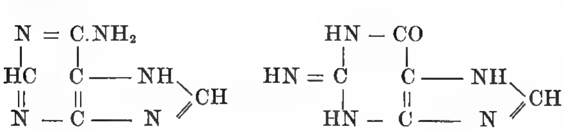
The possibility of a direct formation of urea from proteids is no longer excluded. By direct oxidation with permanganate in the presence of ammonia at 40° C. Hofmeister has succeeded in obtaining urea from various substances, both nitrogenous and non-nitrogenous. There is at present no experimental evidence to suggest that such oxidative syntheses actually occur in the body. Another source of urea may be found in arginin, $C_6H_{14}N_4O_2$, which is formed by the hydrolytic cleavage of proteids and by digestive enzymes. Arginin yields urea on decomposition as follows:



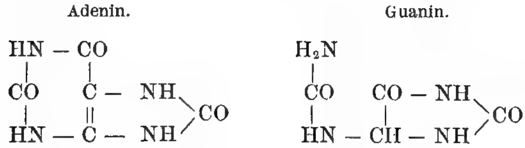
Arginin. Water. Urea. Ornithin.

Gulewitsch has detected arginin in the spleen of the ox, and thus demonstrated that it may occur in the body. In view of all these facts, it is quite possible that urea may arise in a number of ways in metabolism and include one or more of the processes outlined. Other theories have been advanced in the past; but none of them has anything more decisive in its favor.

Of the purin derivatives (alloxuric bodies, xanthin bases) excreted in the urine, *uric acid* is the most important. In birds and reptiles it forms the chief nitrogenous end-product of metabolism, and results from synthetic processes taking place in the liver. In man and other mammals the origin of the uric acid is quite different. Here it represents one of the metabolic products of the nucleic acids. The latter are present in the diet in variable quantities and occur in nature in the so-called nucleoproteids (nucleates) which are salts of proteids with nucleic acid. On decomposition the nucleic acids yield one or more of the purin derivatives, usually adenin or guanin, which undergo oxidation in the body. Uric acid is an intermediate stage in the complete decomposition; when introduced as such into the body it is largely burned up. In some animals a further stage in the oxidation process, viz., allantoïn, is found in the urine after ingestion of uric acid or of nucleates. The relationship between these compounds is indicated by their structural formulæ:



Adenin. Guanin.



Uric acid. Allantoïn.

Experiments by the writer and others make it probable that the liver is the seat of the oxidations referred to. There is no evidence that the spleen is involved, as has been assumed. While the possibility of a synthetic formation of uric acid has not been absolutely excluded, it cannot play any important rôle under ordinary conditions. In the absence of purin compounds in the diet, the uric acid output in man does not ordinarily exceed 300 mgm. per day. Uric acid bears no direct relation to urea in metabolism, although the latter may be formed from it.

Hippuric acid (benzoyl-glycocoll) is a synthetic product formed through the agency of the kidney cells. The benzoic acid radical is introduced into the body with the diet, while glycocoll ($CH_2[NH_2]COOH$) is without doubt one of the intermediary products of proteid katabolism. It can be obtained directly from most proteids by hydrolytic cleavage.

Creatinin in the urine represents, for the most part, ingested creatinin, or creatin which is largely changed into creatinin in the body. The fact that neither of these compounds undergoes metabolism with production of urea or anything else accords with the general belief that these substances cannot build up proteids and presumably do not form an intermediate step in the formation of urea. The relation of creatin to creatinin is shown below:

Creatin.

Creatinin.

What becomes of the "carbon moiety" of the proteid molecule, that large fragment which is not drawn upon in the formation of urea? Can it be stored in the body when not called upon for oxidation? Most physiologists have assumed that it may serve to build up fat or even glycogen under proper conditions. The criticisms of Pflüger and his school have thrown doubt upon many of the supposed instances of fat or glycogen formation from proteid. The "fatty degeneration" of organs has long been a favorite illustration of a similar reaction; but the tendency of modern research is to refer this phenomenon to a process of infiltration of fat imported from other parts of the body. In other cases the proteid is assumed to conserve the fat or glycogen of the body by its own oxidation and thus simulate fat or glycogen formation. The formation of tissue fat from the fats and carbohydrates of the diet is unquestioned; and while the data at hand regarding the direct formation from proteid may be unsatisfactory, the possibility of such a reaction can scarcely be denied. Carbohydrates are readily stored up as glycogen in the liver and muscles, and may also be found in other active tissues. The extent to which glycogenesis may go on is after all rather limited; and the unused carbohydrate may be deposited as fat for which there is an almost unlimited depot. How extensive distinctly synthetic processes may become, on the other hand, is illustrated in the transformations which result in the formation of milk within the mammary glands. The proteid, carbohydrates, and fat content of this secretion are almost entirely made up of compounds not found elsewhere in the organism.

The chemical changes within the individual organs and tissues have been referred to incidentally in various connections. The muscles are doubtless the most important in point of metabolic activity, owing to the large amount of contractile tissue in the whole body and to the vigorous oxidation going on in this. Among the glandular organs the liver stands pre-eminent as the seat of a series of important physiological functions, chemical in nature. In addition to glycogenesis and the reverse process by which sugar is again set free, the formation of urea from ammonia and amido compounds, and the oxidation or synthesis of uric acid, the liver is responsible for the formation of bile pigment from the blood constituents; for the preparation of cholic acid from antecedents not yet known and the origin of the conjugate bile acids; for the synthesis of the ethereal sulphates of the urine; for processes by which many toxic substances are rendered inert; and finally for a series of chemical processes of which we know only the merest outlines. The metabolic changes in the other gland cells are doubtless of a simi-

lar nature, although they may be less extensive or variable. In the salivary glands, for example, constructive metabolism goes on coincidently with secretory activity, and the glands tend, so to speak, to remain in nitrogenous equilibrium.

The importance of certain organs for metabolism is made evident by the effects of their removal from the body. After splenectomy or after extirpation of the salivary glands no marked general effects are apparent; and to a lesser degree this is true with reference to the ovaries and testes. On the other hand, the loss of the thyroids, the adrenal glands, the pituitary body, and the pancreas is in each case immediately followed by serious and usually fatal disturbances in metabolism. The functions of the "internal secretions" of such organs are slowly being exposed, and we may hope that the near future will greatly enlarge our knowledge of metabolism within the individual organs and the cells themselves.

Lafayette B. Mendel.

REFERENCES TO THE LITERATURE.

The following brief list of references to the literature is not intended to be complete in any way, but rather to serve as a basis for any more extended study of metabolism. Many of the experimental data referred to in the article have been taken from the papers here referred to.

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METABOLISM, DISTURBANCES OF.—Under this caption will be considered in a general manner the incomings and outgoings of the food and oxygen essential to the maintenance of both normal and abnormal metabolism, but chiefly the latter. The abnormal changes must not be of sufficient magnitude, however, to cause perceptible macroscopic lesions in the bioplasm constituting the protoplasm of the various organs and tissues of the body, for if they are, the domain of well-defined pathology is entered. These minor deviations in metabolism, which are in all instances the precursors of well-marked lesions, are best determined by a quantitative study of the intake and output from the system of the nitrogen and carbon supplied in the food ingested.

For practical clinical purposes, however, this study is confined largely to the estimation of the elimination of the nitrogen in the urea, and of the many excretory by-products of which nitrogen forms an atomic part. Up to the present time this has been necessary because simple and practical methods for estimating quantitatively the elimination of the carbon contained in the excreta have not as yet been devised. On the other hand, if the results of metabolism are to be determined absolutely and with scientific accuracy, perfect quantitative analyses must be made of all the food ingested and of all the nitrogen and carbon eliminated in the excreta. Failure to attain even approximate accuracy in these two directions is the essential reason for most of the errors that have crept into the clinical deductions in connection with this important subject. Much of this error, however, can be eliminated by a careful application of the very accurate estimates and tables, relative to the composition and digestibility of the foodstuffs, that have been worked out by König,[1] Rubner,[2] Atwater,[3] and others.

Beginning with the digestive organs of the alimentary canal, the chief disturbance in their metabolism is indicated by diminution or by arrest of their secretory activity. So far as we know, the chemical composition of the unorganized ferment bodies is not changed. Therefore the modifications in the metabolism of the cells of the salivary glands will be indicated by a diminution in the excretion of ptyalin, or its elimination may be completely arrested. Its absence or its decreased elimination indicates that the bioplasm constituting the epithelial cells of the glands fails to take up the proteid constituents from the blood and isomerically transmute them into ptyalin, to this extent interfering with perfect digestion and later with general metabolism.

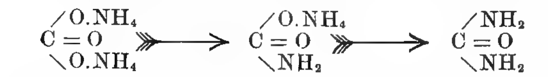
In the stomach similar disturbances are met with, but they are more complicated in character, because the gastric mucous membrane has for its function the production, out of the proteids taken up from the blood, of hydrochloric acid, rennin, and pepsin. Hence, a disturbance in the metabolism of the epithelial cells peculiar to this organ will result in decreased production of hydrochloric acid, rennin, and pepsin. Only one of the three may be decreased or arrested, or all may be absent at the same time from the gastric secretion. In this manner there will be produced varying degrees of disturbance in the metabolic action of the epithelial cells lining the gastric tubules. This will cause varying degrees of disturbance in the gastric digestion and act as another source of general malnutrition and metabolic disturbance.

What has been said regarding the changes in the secretion of salivary organs and of the glands of the stomach applies with equal force to the secretion of the pancreatic gland. Here, however, owing to the more complex function of the gland so far as its secretion is concerned, disturbance in its metabolism is more varied in character and disastrous in its results. There may be a diminution or an arrest in the secretion of the amylopsin, trypsin, or steapsin. One or all may be involved, thus indicating varying degrees and kinds of metabolic disturbance in the bioplasm of the cells. The supposed milk-curdling ferment of the pancreatic secretion may be defective or absent, and this indicates still another type of disturbance.

The same may be said of the glands and follicles contained in the mucous membrane of the intestinal wall, all of which point to a disturbance in the metabolic function or bioplasm constituting the cells that enter into their formation.

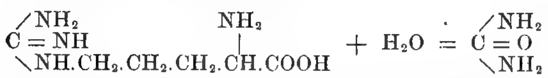
While it is impossible from a practical standpoint to secure directly the secretion of the pancreatic gland and that of the intestinal glands for analysis in the human subject, indirectly we are readily made aware of a decrease or arrest in the output of the enzymes contained in these secretions by an imperfect digestion of the foodstuffs, or by a putrefactive instead of the normal fermentation of the starches, sugars, fats, and proteids contained in the food.

The decrease or arrest of the hepatic secretion must also be taken into account in the study of disturbed metabolism when analyzed from the digestive viewpoint. While the bile is not generally considered as important a digestive fluid as some of the other glandular secretions that are poured into the alimentary canal, it cannot be eliminated from this problem of disturbed metabolism.

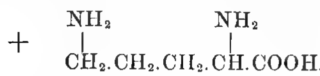


Ammonium carbonate. Ammonium carbamate. Urea.

The possibility of a direct formation of urea from proteids is no longer excluded. By direct oxidation with permanganate in the presence of ammonia at 40° C. Hofmeister has succeeded in obtaining urea from various substances, both nitrogenous and non-nitrogenous. There is at present no experimental evidence to suggest that such oxidative syntheses actually occur in the body. Another source of urea may be found in arginin, $C_6H_{14}N_4O_2$, which is formed by the hydrolytic cleavage of proteids and by digestive enzymes. Arginin yields urea on decomposition as follows:



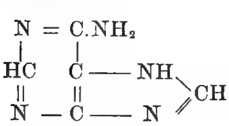
Arginin. Water. Urea.



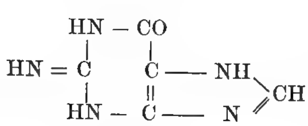
Ornithin.

Gulewitsch has detected arginin in the spleen of the ox, and thus demonstrated that it may occur in the body. In view of all these facts, it is quite possible that urea may arise in a number of ways in metabolism and include one or more of the processes outlined. Other theories have been advanced in the past; but none of them has anything more decisive in its favor.

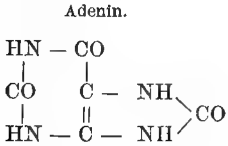
Of the purin derivatives (alloxuric bodies, xanthin bases) excreted in the urine, *uric acid* is the most important. In birds and reptiles it forms the chief nitrogenous end-product of metabolism, and results from synthetic processes taking place in the liver. In man and other mammals the origin of the uric acid is quite different. Here it represents one of the metabolic products of the nucleic acids. The latter are present in the diet in variable quantities and occur in nature in the so-called nucleoproteids (nucleates) which are salts of proteids with nucleic acid. On decomposition the nucleic acids yield one or more of the purin derivatives, usually adenin or guanin, which undergo oxidation in the body. Uric acid is an intermediate stage in the complete decomposition; when introduced as such into the body it is largely burned up. In some animals a further stage in the oxidation process, viz., allantoïn, is found in the urine after ingestion of uric acid or of nucleates. The relationship between these compounds is indicated by their structural formulæ:



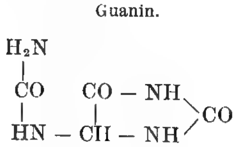
Adenin.



Guanin.



Uric acid.

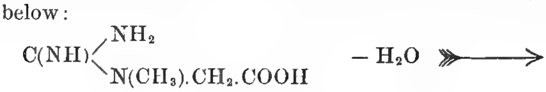


Allantoïn.

Experiments by the writer and others make it probable that the liver is the seat of the oxidations referred to. There is no evidence that the spleen is involved, as has been assumed. While the possibility of a synthetic formation of uric acid has not been absolutely excluded, it cannot play any important rôle under ordinary conditions. In the absence of purin compounds in the diet, the uric acid output in man does not ordinarily exceed 300 mgm. per day. Uric acid bears no direct relation to urea in metabolism, although the latter may be formed from it.

Hippuric acid (benzoyl-glycocoll) is a synthetic product formed through the agency of the kidney cells. The benzoic acid radical is introduced into the body with the diet, while glycocoll ($CH_2[NH_2]COOH$) is without doubt one of the intermediary products of proteid katabolism. It can be obtained directly from most proteids by hydrolytic cleavage.

Creatinin in the urine represents, for the most part, ingested creatinin, or creatin which is largely changed into creatinin in the body. The fact that neither of these compounds undergoes metabolism with production of urea or anything else accords with the general belief that these substances cannot build up proteids and presumably do not form an intermediate step in the formation of urea. The relation of creatin to creatinin is shown below:



Creatin.

Creatinin.

What becomes of the "carbon moiety" of the proteid molecule, that large fragment which is not drawn upon in the formation of urea? Can it be stored in the body when not called upon for oxidation? Most physiologists have assumed that it may serve to build up fat or even glycogen under proper conditions. The criticisms of Pflüger and his school have thrown doubt upon many of the supposed instances of fat or glycogen formation from proteid. The "fatty degeneration" of organs has long been a favorite illustration of a similar reaction; but the tendency of modern research is to refer this phenomenon to a process of infiltration of fat imported from other parts of the body. In other cases the proteid is assumed to conserve the fat or glycogen of the body by its own oxidation and thus simulate fat or glycogen formation. The formation of tissue fat from the fats and carbohydrates of the diet is unquestioned; and while the data at hand regarding the direct formation from proteid may be unsatisfactory, the possibility of such a reaction can scarcely be denied. Carbohydrates are readily stored up as glycogen in the liver and muscles, and may also be found in other active tissues. The extent to which glycogenesis may go on is after all rather limited; and the unused carbohydrate may be deposited as fat for which there is an almost unlimited depot. How extensive distinctly synthetic processes may become, on the other hand, is illustrated in the transformations which result in the formation of milk within the mammary glands. The proteid, carbohydrates, and fat content of this secretion are almost entirely made up of compounds not found elsewhere in the organism.

The chemical changes within the individual organs and tissues have been referred to incidentally in various connections. The muscles are doubtless the most important in point of metabolic activity, owing to the large amount of contractile tissue in the whole body and to the vigorous oxidation going on in this. Among the glandular organs the liver stands pre-eminent as the seat of a series of important physiological functions, chemical in nature. In addition to glycogenesis and the reverse process by which sugar is again set free, the formation of urea from ammonia and amido compounds, and the oxidation or synthesis of uric acid, the liver is responsible for the formation of bile pigment from the blood constituents; for the preparation of cholic acid from antecedents not yet known and the origin of the conjugate bile acids; for the synthesis of the ethereal sulphates of the urine; for processes by which many toxic substances are rendered inert; and finally for a series of chemical processes of which we know only the merest outlines. The metabolic changes in the other gland cells are doubtless of a simi-

lar nature, although they may be less extensive or variable. In the salivary glands, for example, constructive metabolism goes on coincidently with secretory activity, and the glands tend, so to speak, to remain in nitrogenous equilibrium.

The importance of certain organs for metabolism is made evident by the effects of their removal from the body. After splenectomy or after extirpation of the salivary glands no marked general effects are apparent; and to a lesser degree this is true with reference to the ovaries and testes. On the other hand, the loss of the thyroids, the adrenal glands, the pituitary body, and the pancreas is in each case immediately followed by serious and usually fatal disturbances in metabolism. The functions of the "internal secretions" of such organs are slowly being exposed, and we may hope that the near future will greatly enlarge our knowledge of metabolism within the individual organs and the cells themselves.

Lafayette B. Mendel.

REFERENCES TO THE LITERATURE.

The following brief list of references to the literature is not intended to be complete in any way, but rather to serve as a basis for any more extended study of metabolism. Many of the experimental data referred to in the article have been taken from the papers here referred to.

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METABOLISM, DISTURBANCES OF.—Under this caption will be considered in a general manner the incomings and outgoings of the food and oxygen essential to the maintenance of both normal and abnormal metabolism, but chiefly the latter. The abnormal changes must not be of sufficient magnitude, however, to cause perceptible macroscopic lesions in the bioplasm constituting the protoplasm of the various organs and tissues of the body, for if they are, the domain of well-defined pathology is entered. These minor deviations in metabolism, which are in all instances the precursors of well-marked lesions, are best determined by a quantitative study of the intake and output from the system of the nitrogen and carbon supplied in the food ingested.

For practical clinical purposes, however, this study is confined largely to the estimation of the elimination of the nitrogen in the urea, and of the many excretory by-products of which nitrogen forms an atomic part. Up to the present time this has been necessary because simple and practical methods for estimating quantitatively the elimination of the carbon contained in the excreta have not as yet been devised. On the other hand, if the results of metabolism are to be determined absolutely and with scientific accuracy, perfect quantitative analyses must be made of all the food ingested and of all the nitrogen and carbon eliminated in the excreta. Failure to attain even approximate accuracy in these two directions is the essential reason for most of the errors that have crept into the clinical deductions in connection with this important subject. Much of this error, however, can be eliminated by a careful application of the very accurate estimates and tables, relative to the composition and digestibility of the foodstuffs, that have been worked out by König,[1] Rubner,[2] Atwater,[3] and others.

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In the stomach similar disturbances are met with, but they are more complicated in character, because the gastric mucous membrane has for its function the production, out of the proteids taken up from the blood, of hydrochloric acid, rennin, and pepsin. Hence, a disturbance in the metabolism of the epithelial cells peculiar to this organ will result in decreased production of hydrochloric acid, rennin, and pepsin. Only one of the three may be decreased or arrested, or all may be absent at the same time from the gastric secretion. In this manner there will be produced varying degrees of disturbance in the metabolic action of the epithelial cells lining the gastric tubules. This will cause varying degrees of disturbance in the gastric digestion and act as another source of general malnutrition and metabolic disturbance.

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While it is impossible from a practical standpoint to secure directly the secretion of the pancreatic gland and that of the intestinal glands for analysis in the human subject, indirectly we are readily made aware of a decrease or arrest in the output of the enzymes contained in these secretions by an imperfect digestion of the foodstuffs, or by a putrefactive instead of the normal fermentation of the starches, sugars, fats, and proteids contained in the food.

The decrease or arrest of the hepatic secretion must also be taken into account in the study of disturbed metabolism when analyzed from the digestive viewpoint. While the bile is not generally considered as important a digestive fluid as some of the other glandular secretions that are poured into the alimentary canal, it cannot be eliminated from this problem of disturbed metabolism.

Transmutation of the food products in the alimentary canal is usually excluded from the discussion of "metabolism," or what the Germans include under the word "*Stoffwechsel*," which, strictly speaking, means exchange of material; although, as Schäfer says in his admirable article on metabolism: "There is no special reason . . . why this should be the case, for the digestive changes in the food must, like all other chemical changes occurring within the body, influence the general conditions of the economy." It is just this fact, that they do directly influence the transmutations which technically are more directly within the body, which makes it so essential to give prominence to the changes in the foodstuffs in the intestinal tract in the discussion of disturbances in metabolism. This is especially true in reference to the putrefactive changes in the proteid constituents of the food resulting from abnormal fermentation of these substances in consequence of defective formation of the enzymes necessary for a perfectly normal transmutation.

While the number of abnormal by-products formed as the result of defective digestion is very large, the one which deserves especial attention in connection with disturbances in metabolism is that substance which has received the name "indican" or "indoxyl potassium sulphate." This substance, by virtue of its combination with the inorganic element potash, obeys the law common to almost all inorganic substances and is readily absorbed as such from the alimentary canal and is eliminated under its own form from the system through the renal glands with the urine. When this occurs its presence is easily detected in the urine.* This substance has been singled out from all the rest because it is easily demonstrated and is therefore of practical utility in determining the slightest deviations from the normal state of the digestive system. It also indicates a disturbance in general metabolism. Indoxyl potassium sulphate, or indican, in the urine denotes primarily putrefactive fermentation of the proteid substances in the alimentary canal. With this putrefactive fermentation, instead of normal peptone only being absorbed, as occurs in a perfect state of the physiological economy, there are other and toxic products formed in the alimentary canal and absorbed with the peptone, saccharine elements, and fats. These toxic substances after absorption are discharged as such into the blood stream. Within the system they act with varying degrees of toxicity and interfere to a greater or less extent with an otherwise perfectly normal isomeric transmutation or oxidation reduction of the proteid molecules. When this occurs, depending upon the kind and amount of toxic substance absorbed or produced within the animal economy in consequence of the presence of these toxic bodies circulating in the blood, there will be produced various retrograde changes in the metabolism of the various organs and tissues of the body. So long as the deviations in the exchange of material in the bioplasm do not give rise to profound changes or only to such as are chemical in nature and do not produce changes recognizable by careful microscopic examination, the process may be classed as a functional disorder, so called, or as simply a disturbance in metabolism. Beyond this point we enter the realm of organized disease. This primary imperfect exchange of chemical substances in the bioplasm, unrecognizable except through changes in the composition of the urine, is unquestionably the beginning of many, if not all, of the more profound disturbances which sooner or later give rise to absolute and easily recognized structural changes in the various tissues and organs of the body. Some of these are so decided as to be readily detected by the unaided eye, while many will require the microscope for their demonstration. These minor disturbances in metabolism lower the nutritive tone of the bioplasm and of the fluids of the body, thus decreasing the resistance of the system against toxic or germ invasion. In this manner a suitable soil is developed in which the various micro-organisms can grow and produce the diseases with which their presence within the animal organism is associated.

Thus it is found that faulty transmutation of the proteid constituents of the food in the alimentary canal is very largely responsible for the disturbances carried on more strictly within the system. Furthermore, the defective transmutation of the foodstuffs in the alimentary tract must be corrected before the disturbances in the metabolism in the inherent structures of the body can be overcome. From a practical therapeutic standpoint, therefore, a discussion of both the extrinsic and intrinsic modifications in the exchange of material is absolutely necessary if a clear understanding of disturbance in metabolism is to be acquired.

Looking into the system, it is necessary still further to consider the pancreas and the results of its defective secretion as an essential factor in the disturbance of metabolism. The experiments of von Mering and Minkowski* and others have conclusively shown that removal of the pancreas prevents a perfect exchange in the carbohydrates and proteids with the appearance of glucose in the urine. These results have been frequently confirmed. It has also been shown that the arrest in metabolism following this operation is entirely independent of any disturbance in the digestive function. Thus, it would appear that certain portions of the pancreatic gland, possibly the cells of the central acini or islands of Langerhans, instead of pouring their secretion into the ducts of the gland, discharge it through intercalary ducts into the blood-vessels or lymph channels from whence it enters the blood. In other words, certain cells of this gland take up from the blood proteid elements and isomerically or otherwise transform them for further use in effecting metabolism, in a manner somewhat similar to the formation of the enzymes that pass out through the main duct to reach the alimentary canal. In this instance, however, the secretion passes back into the system. That this internal secretion is essential for perfect metabolism appears to be conclusively established. Therefore, if the system is deprived of this particular isomeric form of proteid which has re-entered the blood, either by removal of the pancreas or by the introduction into the system of artificial chemical substances that destroy the special secretory power of the gland, the normal exchange in the food elements is interrupted and glucose appears in the urine. It is also possible that chemical substances are at times developed within the system that may arrest this particular function of the gland, thus causing the appearance of glucose in the urine. However it is brought about, the presence of glucose in the urine always indicates an abnormal exchange within the system. In this particular instance it is indicative of metabolic disturbance in the bioplasm in these special cells of the pancreas as well as of imperfect exchange in the carbohydrates and proteids. On the other hand, if it can be unquestionably established that such an internal secretion of the pancreas is always absolutely essential for perfect transmutation of the carbohydrates and proteids, and that only a suspension of or decrease in this special function causes arrest of exchange in the substances enumerated, then the etiology of diabetes will be greatly simplified, even though there are many diverse conditions that appear to give rise to the excretion of glucose in the urine. Thus far it has not been possible to arrest this form of metabolic disturbance by the administration of raw pancreas or by the use of extracts made from the gland, as can be done with some of the so-called internal glands—the thyroid, for example.

Owing to the great uncertainty in regard to the exact status of normal fat exchange, it is impossible to give any clear exposition of disturbances in its metabolism.

The secretions of the various so-called internal glands, for instance the thyroid, pituitary body, and suprarenals, must also be considered in the elucidation of disturbances of metabolism. It seems reasonably certain that

* See Jaffe's test, under *Urine*.

* Arch. f. exp. Path. u. Pharmakol., Bd. xxvi.; Minkowski, *ibid.*, Bd. xxxi., p. 85.

the bioplasm of the cells constituting these organs possesses the power of taking up from the circulation some of its proteid constituents. The proteid thus absorbed in passing through the cells of the various organs is isomerically or otherwise transformed and is then either discharged directly into the blood or it reaches this fluid by way of the lymphatic channels. On the other hand, the proteid taken up by the cells might be there changed by a process of oxidation reduction, thus causing the essential chemical element in the blood to establish perfect metabolism. It seems more probable, however, from the general absence of oxidation reduction products in the blood, that the change is one of isomeric transformation and of such a nature as to cause the proteid elements thus transformed to differ in their chemical activity, thus making them essential to the normal exchange constituting metabolism.

There are two theories advanced in explanation of the mode of action of these glands. One is that the newly formed substance is toxic in nature and gives rise to "autointoxication" of the system. The other theory is that the substance formed is not toxic, but is elaborated in a manner similar to that described in connection with the internal secretion of the pancreas; and, furthermore, that this newly formed substance is proteid in character but not necessarily a ferment, since it is concerned chiefly in metabolic exchange of proteids. This is shown by the fact that removal of the thyroid or its destruction by disease has a decided tendency to arrest the normal exchange between the blood plasma and the connective tissue, the disturbance being so great as to cause a peculiar hyperplasia of the connective tissue. The proteid molecules enter into the construction of the tissue and occupy, as it were, a larger volumetric space than normally is the case. This gives rise to a peculiar appearance of the tissue, so much so that the structures seem to be œdematous, but are not so in the strict sense in which that term is usually applied. Minor degrees of interruption in the secretion of the thyroid are unquestionably the cause of many of the lesser disturbances in metabolism in which the changes are not of sufficient magnitude to produce perceptible organic lesions accompanied by characteristic symptoms.

In like manner, the pituitary body produces a secretion which in a measure also seems essential for perfect metabolism, but in a way entirely different from what occurs when the thyroid secretion is interfered with. When the pituitary body is involved, the effect is noticed chiefly in connection with the bones of the extremities and face. In some cases there is also hypertrophy of the skin and mucous membranes, but without the gelatinoid consistency so characteristic of myxœdema. Minor changes of this character appearing before marked "acromegalia" occurs might be classed as disturbances in metabolism.

In a similar manner, the internal secretion of the suprarenal bodies is essential for perfect metabolism. Here the action seems to be more especially confined to exchanges taking place in the muscular tissue. This is noticeable particularly in the muscular tunics of the blood-vessels. Arrest or diminution in the secretion of the suprarenals will, therefore, cause imperfect exchange in the proteids passing from the blood plasma to the muscle structure, and vice versa. So long as the disturbance in the secretion of these bodies is moderate in character, only milder degrees of metabolic derangement result. On the other hand, if the secretion is more completely cut off, graver disturbances in the metabolism of the muscular tissue supervene. Under these circumstances there are developed great muscular weakness, pigmentary discoloration of the skin and mucous membranes, and organic changes such as are commonly found in the condition known as Addison's disease.

Primarily, disturbance in metabolism is the result of a more or less decided arrest of one or more of these various secretions, which are either extrinsic or intrinsic in nature, since they all appear to be essential for perfect exchange between the food and oxygen taken in and the excreta eliminated. These minor disturbances are the forerunners and causative factors in a very large measure of all the more pronounced organic changes. It is, therefore, often very difficult to draw a sharp line of demarcation between a simple disturbance in metabolism and a genuine pathological condition, especially as all lesions are the direct result of imperfect exchange between the food products and oxygen in the bioplasm of the organs and tissues of the body. The innumerable cases met with which present no well-defined symptoms upon which a positive diagnosis of a pathological state of the system can be based, yet in which a wide deviation from the normal standard exists, are good examples of simple disturbances in metabolism. Many of the vague and indefinite nervous conditions constitute another class illustrating disturbances in metabolism.

The chief evidences of disturbance in metabolism are found in the katabolic products excreted in the urine. First in importance among these katabolic bodies is indoxyl potassium sulphate, already referred to in connection with disturbances of digestion. This substance is easily detected in the urine, and indicates the normal or abnormal performance of the digestive transmutation of the proteids, the quantity determining in a general way the degree of digestive disturbance. A rise and fall in the amount of indican eliminated in the urine is evidence of increase or decrease of putrefactive fermentation of the proteids of the food in the intestine. Therefore careful daily estimation of the output of indican gives a comparatively exact idea of the state of the digestive system so far as the proteids are concerned. Its presence or absence is also, in a large measure, an index of the degree of intoxication of the system and of perfect and imperfect metabolism, because perfection in metabolism is chiefly dependent upon perfection of digestion.

Although uric acid is one of the normal constituents of the urine, its occurrence in excess of a certain amount is abnormal. When excreted in normal amount, it is combined chiefly with sodium or potassium as a urate. As a rule, uric acid is not found free in the urine. Imperfect metabolism and incomplete oxidation of the proteids give rise to free uric acid in the urine, and often in great quantities. This always indicates imperfect oxidation of the proteid constituents. Under these circumstances, estimation of the excess of uric acid and determination of the amount produced daily render it possible to detect the slightest imperfection of oxidation.

With more profound disturbances in the transmutation and oxidation reduction of the proteid elements, oxalic and lactic acids, glucose, and albumin appear in the urine. Excretion of oxalic acid with an excess of the phosphates usually indicates metabolic disturbances largely confined to the nervous tissue. Lactic acid is generally associated with those conditions commonly classed as rheumatic. Glucose is usually found in connection with diabetes. As rheumatism and diabetes belong in the domain of well-defined pathological conditions, they are beyond the limits of simple disturbances in metabolism. The same is, in a measure, true of albuminuria. The intermittent and transitory appearance of traces of albumin in the urine (cyclic albuminuria) may be regarded as evidence of simple disturbance in the exchange of the proteid materials. On the other hand, if albumin is persistent and present in considerable quantity, it must then be considered as indicative of a profound and often serious disturbance in metabolism.

As the starches, sugars, and fats are, in all probability, rapidly converted and oxidized directly into carbon dioxide and water, it is very difficult to trace their perfect or imperfect exchange and oxidation. The same is, in large measure, true in regard to their transit through the alimentary canal. If we accept the theory of glycogen formation from saccharine compounds, and that the glucose in the urine is the result of imperfect transformation of glycogen, then the presence of glucose in the urine indicates imperfect transformation of the starches and sugars. On the other hand, if we accept the more probable theory and one which is more in harmony with well-

known chemical laws—namely, that the glucose in the urine is the result of imperfect transmutation and oxidation reduction of proteid elements—there are no definite methods for practically determining from the composition of the urine whether the saccharine elements are perfectly or imperfectly exchanged. In a general way, if nutrition is well sustained and the urine practically normal, it is reasonable to suppose that all the ingredients of the food are perfectly transformed and that metabolism is normal. On the other hand, if the urine contains abnormal nitrogenous katabolic bodies and there is positive loss of flesh, this is conclusive evidence that the sugars and fats are imperfectly exchanged. Under similar circumstances, if there is rapid production of adipose tissue, it is reasonable to suppose that the sugars and fats are concerned in this disturbance in metabolism.

With this understanding of the conditions deserving of classification as simple disturbances in metabolism, they must be regarded as largely responsible for most of the graver states of the system, which must be combated as definite diseased conditions. These minor disturbances in metabolism must be recognized and corrected early in their development in order to prevent more serious disturbances. If recognized in their incipiency these trivial disturbances in metabolism can, in many instances, be arrested in their progress by close attention to the diet, to digestion, and to hygienic surroundings. Diet and digestion, however, are the chief elements to be considered if even the milder forms of disturbance in metabolism are to be successfully dealt with.

William Henry Porter.

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METACHLORAL.—This body is polymeric with chloral (not chloral hydrate), having the formula $C_6H_3Cl_9O_3$. It is formed from chloral by the action of concentrated sulphuric acid, and is a solid body distinguishable from chloral hydrate by being insoluble in water. It appears to have an influence over animal physiology akin to that of chloral hydrate, but it is not an official medicine.

Edward Curtis.

METACRESOL-ANYTOL (see *Anytin*) is a forty-per-cent. solution of metacresol in anytin. Löffler called attention to its powerful bactericidal qualities, and Schwab showed that a two-per-cent. solution (metasol) is indifferent to instruments and does not lose its antiseptic power in the presence of albuminoids. Seybolds noted no ill effect on animals from eight minims per kilogram of body weight. Koelzer painted erysipelatous areas and the neighboring healthy skin with a 7.5-per-cent. aqueous solution with excellent results. Used in full strength the preparation is capable of setting up dermatitis.

Metasol is a trade name for one- and two-per-cent. solutions of metacresol anytol. *W. A. Bastedo.*

METACRESOL CINNAMIC ESTER is a mixture of metacresol and cinnamic acid heated and acted upon by phosphorus oxychloride. It is insoluble in water, but soluble in alcohol, ether, and chloroform. It has been proposed as a local application in laryngeal tuberculosis, and as an inhalant for both laryngeal and pulmonary tuberculosis. *W. A. Bastedo.*

METAPLASIA.—The direct transformation of one tissue into another without the formation of an intermediate embryonal tissue is known as metaplasia. Such a change can occur only in tissues closely related to one another genetically, as are the different forms of connective tissue Under certain conditions any one of these may become changed into another; thus, fibrous connective tissue may become adipose or myxomatous tissue, cartilage may be changed into bone, lymphadenoid tissue into fat tissue, etc. In the majority of these changes the intercellular basement substance is chiefly affected; thus, in the transformation of connective tissue into cartilage, the basement substance loses its fibrillæ and becomes homogeneous; by a further change into a denser hyaline substance it may assume an osteoid character, and this through the deposit of lime salts may become bone-like. Likewise, in the change of fibrous tissue into myxomatous tissue the basement substance undergoes a mucoid change. On the other hand, in the transformation into fat tissue the change is brought about by the connective-tissue cells themselves taking up the fat; so also in the change into myxomatous tissue the cells become stellate; in the case of cartilaginous or bony metaplasia they assume the characteristic appearance of either cartilage or bone cells.

That epithelial metaplasia occurs is still a matter of some doubt; the change of tall columnar cells into squamous cells, which apparently takes place under certain pathological conditions, while theoretically explainable as a true metaplasia, is probably in the majority of cases brought about through the agency of intermediate stages of cell forms which are essentially embryonal cells. In the upper respiratory tract such changes may take their origin from the small islands of squamous cells found there normally, these increasing in size under certain pathological conditions. In other cases the apparent epithelial metaplasia may be explained by the presence of fœtal inclusions of undifferentiated tissue or by a transplantation of neighboring squamous epithelium.

Metaplasia of connective tissue into epithelium or of epithelium into connective tissue can never occur—a change of type is not possible: *omnis cellula e cellula ejusdem generis.* The older conception of metaplasia, now and then revived, that epithelium may arise from connective tissue, lymphocytes from connective-tissue cells, tissue cells of every kind from leucocytes, etc., receives scanty support at the present day. The accepted idea of metaplasia is that of a variation in cell forms due to changed conditions,—not a change of type. The cell types of the body may be regarded as being of as fixed a nature as the species of the animal and vegetable worlds; variation occurs to a slight extent and only between closely related forms.

As examples of physiological metaplasia may be mentioned the formation of adipose and myxomatous tissues from fibrous tissue, the development of fatty marrow from lymphoid, or in old age the change of the former into a gelatinous or mucoid marrow, the old-age atrophy of lymphadenoid structures into fat and connective tissue, etc.

Pathological metaplasia is for the greater part of a retrogressive nature, as in the transformation of fibrous tissue, bone, and cartilage into myxomatous tissue. The process is also closely associated with progressive changes, inasmuch as it is a constant occurrence in certain forms of tumors. It is very difficult to draw a definite line of separation between the degenerative and the progressive features of the process; in many cases metaplasia may be regarded as standing between degeneration and growth. In so far as the metaplasia itself is concerned there is no new formation of cells, only a change of those already formed. In quickly growing tumors, however, metaplasia may occur so rapidly as to assume the character of a direct new formation. Moreover, developmental changes often follow as well as precede the metaplasia. On the other hand, the tissue resulting from the metaplasia is practically always of a lower type and not infrequently of a perishable nature as shown by its tendency to necrosis. The degree and rapidity of both progressive and degenerative processes depends largely upon the vascular supply; an abundant supply of blood favoring the former, a poor one the latter process.

The occurrence of pathological metaplasias may be explained by the assumption that the cells of closely related tissues possess common potentialities which, under normal conditions of growth, are latent or subordinated to their specific qualities. Under such pathological conditions as

inflammation, disturbance of function, changed nutrition, etc., these latent qualities assert themselves even to such an extent as to result in the changing of the character of the tissue. The potentialities of the germ layers are distributed during the development of the body in an unequal degree among the cells arising from these layers, so that, with the exception of cells genetically widely separated, not only special but also like potentialities are represented in these cells in varying degree. The more closely related are the cells genetically, the greater the degree of common potentialities. Metaplasia in fœtal tissues should therefore be much more possible than in later life, since in the former the individual cell forms are less differentiated and possess more qualities in common. This point is of great importance with reference to the origin of tumors. From indifferent cell material in the form of fœtal "inclusions," "rests," etc., a great variety of tissues might arise in later life. The mixed sarcomas of the kidney, some of the teratoid growths, the formation of cartilage and bone in connective tissues, etc., may be explained in this way.

The most common form of metaplasia is the transformation of fibrous connective tissue into adipose tissue. This is brought about by the taking-up of large amounts of fat into the connective-tissue cells, the latter becoming changed into the large round cells characteristic of adipose tissue. Fatty metaplasia is one of the most common physiological processes; it occurs pathologically in connective tissues which ordinarily do not contain fat, in cases of fatty infiltration. As a result of atrophy or of changed conditions of nutrition the fat tissue may be changed back into fibrous tissue. Not infrequently after disappearance of the fat there is a formation of myxomatous tissue, a mucoid substance being formed in the intercellular substance. On the other hand, mucous tissue may become changed to fatty, the stellate cells taking up fat and becoming changed into round fat cells. Lymphadenoid tissue is also closely related to fatty, and there are evidences of frequent physiological variation between these two forms of tissue. In atrophic lymph glands and in the change of lymphoid to fatty marrow there is first a removal of the lymphoid cells and a change of the reticular cells to fat cells. In the development of lymphadenoid tissue from connective and adipose tissues the fat is removed from the cells in the case of the latter, the connective-tissue fibrillæ become loosely arranged, a portion of the cells becoming changed into reticular cells, while at the same time there is an infiltration of round cells in the reticular meshes.

Myxomatous metaplasia occurs physiologically in the adult body in the bursæ, synovial membranes, and tendon sheaths; pathologically in inflammatory conditions of these structures, and particularly in the connective tissue of certain neoplasms. Fibrous and adipose tissues, bone, and cartilage may become changed into myxomatous tissue; in the case of fibrous tissue the fibrillæ disappear, the basement substance undergoes a partial liquefaction with the formation of mucin, while the spindle cells become changed into stellate or irregularly branched cells.

In the case of bone or cartilage there is a liquefaction of the basement substance with mucin formation, the bone or cartilage cells becoming changed to stellate or anastomosing branched forms.

Cartilaginous and osseous metaplasias occur in the connective tissue of the large arteries and of the cardiac valves, in the subcutaneous and intermuscular connective tissue, also in newly formed connective tissue in the eyeball, and in the stroma of both the mature connective-tissue tumors and sarcoma, more rarely in that of carcinoma. The basement substance loses its fibrillar character and becomes homogeneous in the change into hyaline cartilage, the connective-tissue cells assuming the appearance of cartilage cells. Fibrous cartilage may be formed by the development of fibrillæ of collagenous material in the hyaline matrix. With the deposit of lime salts in the hyaline intercellular substance and the change of the cartilage cells into bone cells, bone may be formed directly from the cartilage. Bone may also be formed directly from fibrous tissue by the change of the fibrillar intercellular substance into an osteoid substance which later becomes calcified; the connective-tissue cells lying in the spaces appear as bone cells. Cartilage may become changed into fibrous tissue, but there is no evidence that fully formed bone undergoes such a metaplasia.

A metaplasia of unstriped muscle into striped as well as the reverse process has been claimed by many observers to occur under various pathological conditions, particularly in the case of the mixed sarcomas of the kidney. It is very probable, however, that these neoplasms are due to congenital inclusions of the myotome, and are not to be regarded as examples of true metaplasia of adult tissues.

Except in the case of tumors, myxomatous, cartilaginous, and osseous metaplasias must be regarded as of fairly rare occurrence. They are found very often in the mixed connective-tissue tumors and in certain forms of sarcoma, particularly those arising from periosteal or intermuscular connective tissue. Both myxomatous and cartilaginous metaplasias are very common in the mixed endothelial tumors arising from the salivary and lachrymal glands, less common in those of the mammary gland and testicle. It should be remembered, however, that the presence of bone and cartilage in these growths may be explained also on the ground of inclusions of fœtal tissue. The ossification of the costal, tracheal, and laryngeal cartilages is of such frequent occurrence as to fall within normal limits and is hardly to be regarded as a pathological metaplasia except under extraordinary conditions. The change occurs more rarely in the bronchial cartilages.

The metaplasia of lymphoid out of fatty marrow occurs in leukæmia and the various forms of anæmia. Very rarely marrow-like tissue is found in the spleen and lymph glands. Whether this is to be regarded as metaplasia or as metastasis is not settled. Metaplasia of adipose tissue into lymphoid occurs also after removal of regional lymph glands, splenectomy, etc. Such metaplasia is to be regarded as regenerative or compensatory in nature.

The so-called metaplasia of epithelium is limited to the transformation of columnar into squamous epithelium or the reverse process. In inflammatory processes of the upper respiratory tract (ulceration, ozæna, etc.), in the urethra following chronic gonorrhœa, in the endometrium (chronic endometritis, inversion, ichthyosis uteri, uterine polypi projecting into the vagina or beyond the vulva, etc.), in chronic inflammations of urinary and gall-bladders, kidney pelvis and oviduct, and in chronic inflammation of ear polypi arising in the middle ear and perforating the tympanum, transitional or columnar epithelium may be replaced by squamous. In all these cases the chronic inflammatory process leads to frequent desquamation or necrosis of the epithelium, this being followed by regeneration, the newly formed epithelium being of the squamous type. On the other hand, the transitional epithelium of the bladder may be changed to columnar in the case of bladder papillomata.

As a result of such epithelial metaplasia new growths of the nature of epidermal or squamous-celled carcinoma (cancroid) may arise in regions normally covered by transitional, columnar, or ciliated epithelium. The cases reported of cancroid of bladder, kidney pelvis, endometrium, and gall-bladder have been explained in this way, but the possibility must also be considered that these arise from congenital misplacement of squamous cells or from ingrowths or transplantations from neighboring squamous epithelium (in the case of the endometrium, from the epithelium of the cervix). Columnar-celled or adeno-carcinoma may arise from the columnar cells of bladder papillomata. *Aldred Scott Warthin.*

METASTASIS.—The transportation of substances from one part of the body to another, the transportation of disease-producing agents, the production in one part of the body of a local disease from a primary focus of similar disease in some other part not immediately adjacent,

are various meanings covered by the term metastasis. The word owes its technical origin to the old humoral pathology, and originally signified the beginning of new paroxysms of disease in other parts of the body due to acrimony of the humors, the diseased humors (acrimonia) taking their origin from the incomplete ripening or digestion (critical secretion, apostasis) of acrimonia at the primary seat of disease, the unripe humors being transferred (metastasis) to other parts of the body to complete their crisis. With the passing of the humoral theory the term lost its original meaning, and came to be applied to the transportation of any substance from one part of the body to another by way of the blood or lymph.

Traces of the original idea are still found in the occasional incorrect use of such expressions as dyscrasic, gouty, or rheumatic metastasis, the metastasis of dyscrasic substances in certain eruptive diseases and skin lesions, the metastasis of mumps to the mammary gland and testicles, etc. The older uses, such as *metastasis of secretions* (the explanation of milk leg and puerperal fever through cessation of milk secretion and lochial discharges), *metastasis of blood* (vicarious bleeding in suppressed menstruation), *metastasis ad nervos* (reflex nervous disturbances), have completely disappeared before the modern conceptions of these conditions.

In a broad sense the term metastasis is at the present time applied to the transportation, within the body, of any substance from one part to another (bile and blood pigment, dust, lime salts, uric acid, silver, lead, extrinsic pigments, air, fat, parenchymatous cells, animal and vegetable parasites and cells of malignant tumors). With the exception of the last two classes such transportation is frequently discussed under the head of embolism or pathological deposits, the conception of metastasis being narrowed to the idea of the transportation of a definite agent of disease and the production of the specific disease at the point of deposit of said agent. By many writers metastasis is accordingly limited to two processes only: tumor metastasis and metastasis of bacteria. For this limitation of meaning there is no good reason beyond the fact that these two classes of metastatic processes outweigh in pathological importance all other forms. Moreover, the result of metastasis, that is *metastatic disease*, should not be confounded with the *process of metastasis*.

The most rational classification of metastasis is that given by Ziegler, which is based upon the character of the transported body. Six groups are distinguished:

1. Insoluble substances: dust, stone, coal, metal, pottery clays, tobacco, hair, tattoo pigments, etc.
2. Parenchymatous cells (liver, spleen, placental, and bone marrow), portions of tissues, blood coagula, fat, etc.
3. Cells of malignant tumors.
4. Animal and vegetable parasites.
5. Soluble substances arising within the body or introduced from without and deposited in an insoluble form: blood and bile pigments, lime salts, silver, etc.
6. Air.

According to the method of transportation the following forms of metastasis may be distinguished: *lymphogenous*, through the lymph channels; *hæmatogenous*, through the blood stream; *implantation metastasis*, transportation upon a free surface; *transplantation metastasis*, from one tissue to another or from one animal to another. Transportation in the direction of the blood or lymph streams is known as *direct*, in the opposite direction as *retrograde* metastasis, while the passage of any substance from the venous to arterial circulation without passing through the lungs, as through a persistent foramen ovale or ductus Botalli, is styled *crossed* or *paradoxical* metastasis.

Hæmatogenous Metastasis.—This is the most common form of metastasis; any of the substances mentioned in the above six classes may gain entrance to the blood stream and be carried to other parts of the vascular system to be deposited in those vessels of such small lumen as not to admit of further passage of the transported substance. The point of lodgment and the results of such lodgment depend upon the size and nature of the transported body. Hæmatogenous metastasis is usually direct, but retrograde transportation may occur in the veins, rarely in the arteries. Paradoxical or crossed metastasis may result from persistent foramen ovale or ductus Botalli. Retrograde metastasis is explained by the occurrence of backward currents set up by abnormal waves of pressure proceeding from the heart, by sudden local disturbances of pressure due to muscular action, etc. As a chief factor in the dissemination of tumor cells and bacteria hæmatogenous metastasis is of the greatest pathological importance.

Lymphogenous Metastasis.—This form of metastasis is of particular importance in the spread of carcinoma cells throughout the body. It is usually direct, but is very frequently retrograde, the current in the lymph channels being much more subject to disturbances of pressure from muscular action, etc.

Implantation Metastasis.—This is the transportation of bacteria or tumor cells and their implantation upon either the mucous or the serous surfaces. Such transportation may be brought about by the influence of gravity, by the movement of ciliated epithelium, by peristalsis, through the agency of fluids, air, etc. In the case of the respiratory tract tubercle bacilli may be carried from a lesion situated high in the respiratory passages into the smaller bronchioles and alveoli by the means of inspiration. Caseating and ulcerating tubercles in the upper portion of the digestive tract may set free bacilli, which, carried by the intestinal contents, may give rise to tuberculous lesions in the lower portion. Such implantations are most likely to occur at the ileo-cæcal valve and in the rectum. Likewise tuberculosis of the kidney may give rise to tuberculous lesions of ureters and bladder. Peritoneal tuberculosis is often accompanied by tuberculosis of the Fallopian tubes and uterus, the downward current from the fimbriated openings of the tubes favoring the production of implantation metastases upon the mucosa of tubes and uterus.

Implantation metastasis plays a very important rôle in the pathology of the peritoneal cavity. The rupture of purulent or tuberculous processes into the cavity gives rise to implantations which are most abundant in the pelvis and lowest portions of the cavity, where the bacteria through the force of gravity are most likely to settle. Similarly, widespread implantation metastases of malignant growths may occur over the peritoneum; particularly in the case of malignant papilliferous cystadenoma and carcinoma of the ovary. The cystocarcinoma of the testicle often gives rise to peritoneal or subperitoneal metastases, which in turn become foci for extensive implantation metastases over the peritoneal surface. Similar processes occur in the pleural and other serous cavities. In the case of kidney carcinoma implantation metastases may occur along the ureter and in the bladder; in ovarian carcinoma, in the mucosa of the tubes, and on the endometrium. It is also probable that similar implantations of carcinoma may occur in the intestinal tract. It is to be remembered that many metastases on free surfaces commonly regarded as implantation metastases are often due to retrograde transport in veins or lymphatics, as has been shown by Kaufmann to be the case in the so-called implantation metastases in the vaginal wall in cases of primary cancer of the cervix. It is possible that the same explanation holds good for the so-called implantation of carcinoma from one labium to another at the point of approximation.

Transplantation Metastasis.—The transplantation of bacteria or tumor cells into previously unaffected tissues through the medium of a wound or abrasion of the surface. Such metastasis may follow surgical operations or such diagnostic procedures as the use of the trocar. Transplantation metastases of carcinoma have occurred in the abdominal wall after tapping in cases of malignant disease of the peritoneum, in the skin incisions after removal of mammary carcinoma, and in operations for carcinoma in other parts of the body. The transplantation of minute bits of carcinoma by operation accidentally or

through intention has led to their growth and the formation of secondary nodules in the new situation. Transplantation of malignant tumors from one animal to another of the same species is also possible. Accidental operative transplantation of either sarcoma or carcinoma must be regarded as of very rare occurrence. On the other hand, such transportation of bacteria is an occurrence only too common. By many writers no distinction is made between implantation and transplantation metastases.

The results of metastasis depend upon the character and size of the transported body. The metastasis of small, bland, insoluble substances such as coal dust, etc., is of relatively slight importance, as the effect upon the tissues at the point of lodgment is slight; if the substance is soluble and chemically active, tissue changes may be produced; bacteria and animal parasites may multiply and set up their characteristic changes; while from the cells of malignant tumors metastatic or daughter tumors may arise. The last two classes are consequently of chief importance in the production of metastatic disease.

Metastasis of Animal and Vegetable Parasites.—Transplantation of echinococcus and cysticercus cysts may follow the rupture or dislodgment of these into the blood stream. Metastasis of Bilharzia hæmatobia, and of the eggs and embryos of the filaria occur, the embryos of the trichina are scattered throughout the body by means of the blood and lymph, and the presence of amœbæ in liver abscesses may be due to a portal-vein metastasis from the intestine.

The metastasis of bacteria plays a rôle of very great pathological importance, particularly in the case of the pyogenic organisms and the tubercle bacillus. The entrance of pus-forming organisms may give rise to metastatic abscesses in any portion of the body. Multiplication of the bacteria does not usually take place to any great extent in the circulating blood, but at the places where they are deposited upon the endothelium of the blood-vessels, most often in the small capillaries of the lung, kidney glomeruli, liver, spleen, brain, etc. At the point of growth the same degenerative and inflammatory changes are produced as in the primary focus: tissue necrosis, leucocyte infiltration, and abscess formation (metastatic abscess, pyæmia). The metastases may be so numerous as to resemble those in miliary tuberculosis (miliary, pinhead abscess). When there is no evident primary focus the infection is spoken of as cryptogenic. The pneumococcus, gonococcus, typhoid bacillus, and colon bacillus may also give rise to important metastatic processes. Tuberculosis in its early stages is a local disease, but the process may become widely disseminated throughout the body by the rupture of caseating tubercles into blood or lymph vessels or through direct involvement of these. When great numbers of bacilli gain entrance to the blood, a general hæmatogenous miliary tuberculosis may be produced; if the number is small, the bacilli may be deposited in one organ only (metastatic local tuberculosis). Rupture of caseating tubercles into the thoracic duct or its afferent branches may also give rise to general miliary tuberculosis. Local metastatic tuberculosis is very common in the kidneys, testicles, bones, spleen, etc. In many cases there is no evident primary focus (cryptogenic tuberculosis). Inspiration metastasis of tubercle bacilli is not infrequent in the respiratory tract; implantation metastasis occurs frequently in the digestive, genital, and urinary tracts and peritoneal cavity. In the case of the higher forms of vegetable parasites metastasis has been observed in actinomycosis (pyæmic actinomycosis), cladothrix infection, thrush, and in blastomycetic dermatitis.

Tumor-cell Metastasis.—Through the entrance of living cells of sarcoma or carcinoma into the blood or lymph vessels secondary or daughter tumors may develop at the point of lodgment of such transported cells. It is to be emphasized in this case that tumor cells and not parasites are transported and that the new tumors arise directly from these transported cells. There is no true analogy between the metastasis of bacterial affections and that of malignant growths. The metastatic secondaries develop by cell division of the transported cells; as growth progresses the blood-vessels and connective tissue of the surrounding structures take part in building up the stroma of the tumor nodule. The changes produced in the surrounding tissue are of the same nature as those at the primary focus modified by the character of the part or organ in which the secondary is located. This action is of the nature of a mechanical destruction by the growing tumor rather than of a toxic nature.

The metastatic growth always bears a close resemblance to the primary, but occasionally the metastases may show more or less variation in character from the primary, as, for example, cornification may be present in the primary of a squamous-cell carcinoma, but absent in the secondaries; or the secondaries of a columnar-celled cancer may contain only flattened cells. As a general rule, however, it may be taken that the metastases resemble the primary in kind.

The number of metastases differs greatly in different cases, depending upon the location of the primary, the size and shape of its cells, the relation of these to the blood or lymph vessels, etc. In some cases the number of metastases may be so great that general miliary carcinomatosis or sarcomatosis may be produced. The size of the metastatic growth bears no relation to that of the primary; enormous secondaries may arise from minute primaries. In some cases the metastases completely overshadow the primary in clinical importance. This is not infrequently the case in carcinoma of the prostate, uterus, and pylorus.

As a rule, metastasis is more common in carcinoma than in sarcoma, owing to the fact that the carcinoma cells grow directly into the lymphatics. It is for this reason that the transportation of carcinoma cells occurs chiefly through the lymphatics, while, on the other hand, that of sarcoma is usually through the blood-vessels, the cells of the sarcoma lying in very close relation to or forming the walls of the blood-vessels contained in the growth. Carcinoma metastases are, therefore, usually found in the lymph glands and in the liver, more rarely in the lungs and spleen, while sarcoma metastases are of frequent occurrence in the latter organs. To this there are numerous exceptions: cancer cells may invade the walls of blood-vessels directly and give rise to hæmatogenous metastases; in the case of kidney carcinoma the renal veins and ascending vena cava are almost always invaded and metastases produced in the lungs. The general principle of lymphogenous metastases in cancer and hæmatogenous in sarcoma will hold good, however, for the majority of cases.

It may be taken as a general rule that tumor metastases are common in organs where primary growths are rare, as in the lungs, liver, and kidneys, and are rare in organs where primary new growths are of common occurrence, as in the stomach, uterus, eye, etc.

The same degenerative processes are found in metastatic growths as in the primary. The secondaries of a mucoid carcinoma usually show a mucoid change, and in the case of primary sarcomata showing cartilaginous or bony metaplasias the secondaries usually show the same changes.

The location of the metastases varies according to the seat of the primary as well as with its nature. Certain laws of probability are, however, shown in the distribution of the secondaries of tumors of certain organs.

The metastases of mammary cancer appear first in the lymph glands of the axilla; after these the supraclavicular and anterior mediastinal glands are involved. Of the viscera the liver, lungs, and brain are most frequently the seat of metastases. In some cases of mammary cancer bone metastases play an important rôle, in other cases they do not occur. Retrograde metastasis through the lymphatics of the skin may also take place.

Metastases of stomach carcinoma occur most frequently in the epigastric, portal, and retroperitoneal lymph glands, peritoneum, and omentum, liver, lungs, ovaries,

and bones. According to Osler metastases occur in primary stomach carcinoma in 86.6 per cent. of cases, according to Welch in 63.4 per cent., according to Ewald in 75 per cent. of cases. Retrograde metastasis may lead to multiple carcinomatous constrictions of the intestines. The metastases of intestinal carcinoma are usually hæmatogenous, through the portal vein into the liver. This is explained by the numerous large and thin-walled vessels in the intestinal coats.

Primary carcinoma of the uterus gives rise to metastases first in the iliac, sacral, and lumbar retroperitoneal glands, later in the liver, more rarely in distant organs. Primary sarcoma of the uterus does not often give rise to secondaries; they are usually found, when they do occur, in the lungs, liver, vagina, and ovaries. Primary carcinoma of the ovary gives rise to secondaries in the retroperitoneal glands and the liver, and more rarely in distant organs. Implantation metastases over the peritoneum are very common; they are more rare in the mucosa of the tubes and uterus.

Both primary carcinoma and sarcoma of the kidneys break into the renal veins and produce metastases in the lungs. The neighboring lymph glands, particularly those near the hilum, are usually quickly involved. In the case of cancer of the left kidney retrograde metastasis into the spermatic vein may occur. In carcinoma and sarcoma of the testis the regional lymph glands are usually affected; hæmatogenous metastasis into distant organs is not infrequent. Retrograde metastasis into the kidney through the renal vein may take place. In the case of the cystocarcinoma of this organ implantation metastases over the peritoneum are very common. They may form the chief clinical feature, the primary being of insignificant size. Likewise primary carcinoma of the prostate very often gives rise to metastases of great clinical importance, while the primary may be but a small nodule. The secondaries are often found in the bones, usually in the large ones. The metastasis is usually through the veins; statical and traumatic influences are potent in the location of the metastasis. In all cases in which carcinomatous growths are found in the bones without evident primary disease the prostate and thyroid should be carefully examined for the existence of a primary.

The secondaries of primary cancer of gall-bladder and pancreas are usually found first in the regional lymphatics and liver, later in the lungs and other organs. Primary carcinoma of the liver rarely gives rise to secondaries, but when they do occur these are hæmatogenous. The metastases of malignant hypernephroma arising either in the adrenals or in the kidneys are usually found in the lungs. Primary carcinoma of the thyroid very frequently gives rise to metastases in the bones, the skull, sternum, and ribs being most frequently involved. In primary sarcoma of the thyroid, bone metastases are less commonly found.

In the case of other organs of the body the general rule of lymphogenous metastasis for carcinoma, hæmatogenous for sarcoma will hold good. There are, however, all possible forms of combinations, the metastases in many cases being determined by various factors: relation of tumor cells to blood and lymph vessels, location of primary, etc.

Besides the metastasis of malignant tumors cases of metastases from apparently benign tumors have been reported. Thyroid adenoma and chondroma of the testis are the benign growths which most frequently give rise to secondaries. The very fact of such metastasis should, however, exclude such growths from the benign category. In the case of the chondroma of the testis the primary growth is probably to be regarded as of the nature of a malignant teratoma. The so-called benign adenoma of the thyroid gives rise to bone metastases which resemble the original tumor. They may be multiple. As the secondary foci are not malignant in character they should be removed by local operation; amputation is not indicated. (See also *Embolism*, *Carcinoma*, *Sarcoma*, etc.)

Aldred Scott Warthin.

METHACETIN (Para-oxymethy-acetanilid). — This compound is a derivative of acetanilid, introduced in 1888 by F. Mahnert as a substitute for phenacetin, to which it is closely allied. Its formula is $C_6H_4OCH_3NHC_2H_3O$, which differs from acetanilid, $C_6H_5NHC_2H_3O$, by substituting, for one atom of H, one atom of the oxymethyl group OCH_3. In phenacetin, $C_6H_4OC_2H_5NHC_2H_3O$, the H atom is replaced by the ethyl group OC_2H_5.

It forms in white, glistening, scaly crystals, without color or faintly reddish; odorless; melting at 127° C.; it has a slightly bitter saline taste; is soluble in water at 60° F., 1 part in 530; in boiling water it dissolves in 12 parts; is freely soluble in alcohol, chloroform, glycerin, and fatty oils. Methacetin possesses antipyretic, antiseptic, and analgesic properties similar to those possessed by phenacetin, which it resembles therapeutically, as well as chemically. It may be administered in all conditions in which phenacetin is employed. The dose for an adult is from five to seven grains.

Methacetin has not been very generally adopted and is not employed to any extent. It was recommended as being particularly serviceable for children and enfeebled persons as it was said to be devoid of toxic action. Experience, however, has shown that its use may be followed by profuse perspiration and signs of collapse.

Physiological experiments have proved that forty-six grains will cause death in a rabbit, producing spasms in the posterior, and later in the anterior, half of the body. After death there is found hyperæmia of all the organs, and the heart is flaccid and filled with blood clots. No hæmoglobin is found in the urine. *Beaumont Small.*

METHENYL-ANISIDINE is a local anæsthetic obtained by prolonged heating of ortho-anisidine with ortho-formic acid ester. *W. A. Bastedo.*

METHENYL DI-PARA-PHENETIDIN is a crystalline compound prepared from para-phenetidin and ortho-formic ester. It is used as a local anæsthetic and in seasickness. *W. A. Bastedo.*

METHONAL, di-methyl-sulfone-di-methyl-methane $[(CH_3)_2C(SO_2CH_3)_2]$ is a hypnotic resembling sulfonal, the di-ethyl-sulfone compound. It is, however, less sedative and of less value than sulfonal. Dose 0.7 to 2 gm. (gr. x.–xxx.). *W. A. Bastedo.*

METHOXY-CAFFEINE, $C_8H_9(OCH_3)N_4O_2$, is a derivative of caffeine, occurring as white acicular crystals or as an amorphous powder. It is given in neuralgia, migraine, etc., and may be used hypodermatically. Dose 0.06 to 0.25 gm. (gr. i.–iv.). *W. A. Bastedo.*

METHYL ALCOHOL.—Methyl alcohol, $CH_3(OH)$, known to the chemist also as *carbinol* and *methol*, is more popularly known under the several names of *pyroligneous spirit*, *pyroxylic spirit*, *wood spirit*, *wood alcohol*, and *wood naphtha*—names taking origin from the fact that methyl alcohol occurs as one of the ingredients of crude wood vinegar, the fluid product of the destructive distillation of wood. Methyl alcohol, when pure, is a thin, colorless fluid, much resembling common (ethyl) alcohol in taste and smell, but, obtained from wood vinegar and unpurified, has both a rank and an offensive flavor and odor. Methyl alcohol resembles ethyl alcohol also in being volatile, inflammable, and miscible in all proportions with water and ether. The two alcohols also mix freely with each other. *Physiologically*, the effects of methyl alcohol are probably very similar to those of common alcohol, but exact experimental researches are wanting. Recent experience, however, seems to show that its effects are more harmful than those of ordinary alcohol. *Therapeutically*, this alcohol has been given, with no very obvious purpose, in a number of diseases; but it is now little used, and it is not official in the United States Pharmacopœia. It has been administered in doses of from five to forty drops, taken in water. Methyl alcohol is useful in the arts as a solvent. *Edward Curtis.*

METHYL ALCOHOL, POISONING BY.—Commercial methyl alcohol (wood spirit, wood naphtha) is very impure and on account of its offensive odor and taste cannot be used for the preparation of drugs or beverages. Recently, however, a purified article has been largely sold under the name of Columbian spirit. This has a faint, not unpleasant odor and a pungent taste. As it is somewhat cheaper than common (ethyl) alcohol, it has been extensively used as a substitute for this. Very little information is available as to the physiological action of absolutely pure methyl alcohol. Dr. Benjamin Ward Richardson stated that it was a light and transient stimulant. It has been shown, however, by recent experience that the continued exposure to the vapors of the commercial purified methyl alcohol, or the repeated drinking of it, produces blindness. In the reported cases, which have occurred principally among varnishers who were using materials prepared with Columbian spirit, or among those using medicines containing the same substance, as a substitution for common alcohol, the blindness has been the prominent symptom. The ophthalmoscope shows optic neuritis with exudations into the retina and subsequent atrophy. The calibre of the retinal vessels is much diminished and the veins are tortuous. In the early stages an absolute scotoma and color blindness are found. The condition is very serious. Recovery, if it occurs at all, is slow. The action is, therefore, more of the type of slow poisoning, similar to that commonly caused by lead compounds. Acute poisoning by methyl alcohol would probably resemble acute poisoning by common alcohol, but this phase has as yet no practical importance.

The only treatment possible for the blindness is removal of the cause. It is not impossible that the Columbian spirit still contains some empyreumatic product which is the cause of the poisonous action.

Henry Leffmann.

METHYL CHLORIDE (Monochlormethane) $CH_3.Cl$.—Obtained by the action of hydrochloric acid upon methyl alcohol, in the presence of zinc chloride. A colorless gas with a sweetish taste and an ethereal odor. It is soluble in one-fourth its volume of water, much more so in ethyl and methyl alcohol, and freely in ether and chloroform. The gas is not very inflammable; when ignited it burns with a greenish flame. At a temperature of —11.4° F., or under a pressure of five atmospheres, it is converted into a liquid, with a specific gravity of .9915, neutral to test paper. This liquid boils and becomes a gas at a temperature of —5.8° F., the change of condition being accompanied by the absorption of a great amount of heat. On account of the rapidity of this change an intense degree of cold is produced, amounting to a fall of 40° or 50° F. or more.

The use of this refrigerant action was applied by Débove, in 1884, as a local anæsthetic for neuralgia and other painful affections. It has been used in sciatica, pruritus, spinal pains after railway accidents, and in the painful joints of rheumatism, and in pleurisy. For this purpose it may be applied directly to the part with a camel-hair pencil, or cotton saturated with it is applied to the skin; the spray may also be used. The most important application of this compound was as a freezing mixture for the performance of minor surgical operations. It was used with decided success in circumcision for phimosis, evulsion of toe-nails, excision of cancer of the lip, opening of mammary abscess, incision for empyema, and many similar painful procedures. This use, however, has been superseded by ethyl chloride, which is a much milder but equally effective anæsthetic. Methyl chloride is much more intense in its action on account of the greater degree of cold that is produced, and its effect is controlled with much greater difficulty. The part is sprayed for two or three seconds only; if the spraying is continued beyond five seconds, the tissues are liable to be blistered and necrosis may follow.

Methyl and ethyl chloride are combined in various proportions and brought to the notice of the profession under various trade names; none, however, is superior to the ethyl chloride.

It has also been suggested as an anæsthetic, and a mixture of ether and chloroform, saturated with the gas, was suggested by Richardson, but no advantage was apparent, and it has failed to receive recognition.

Beaumont Small.

METHYL-CHLOROFORM, CCH_3Cl_3, is similar in anæsthetic power to chloroform, but very rapid and fleeting in its action. It is claimed to be less dangerous. It is recommended as an anæsthetic in short operations.

W. A. Bastedo.

METHYL-GLYCOLLIC ACID PHENETIDID. See *Kryofine.*

METHYL-GLYOXALIDIN. See *Lysidin.*

METHYL IODIDE, *Moniodomethane*, CH_3I. Methylic iodide is a colorless, heavy, ethereal fluid, of specific gravity 2.199 at 0° C. (32° F.), and boiling point 43.8° C. (111° F.). When pure its vapor is anæsthetic after the manner of that of chloroform, but this iodide is easily decomposed, and so is apt to incite the irritant effects due to free iodine. In consequence of this disadvantage methyl iodide has never been given a place among accepted anæsthetics. It was originally proposed by Dr. Richardson in 1868. *Edward Curtis.*

METHYL-LORETIN, para-methyl-meta-iodo-ortho-oxyquinolin-ana-sulfonic acid, $CH_3I.OH.C_9H_3N.SO_3H.H_2O$, is a deep yellow compound occurring in scales or needles, slightly soluble in alcohol and water and insoluble in ether. Its action and uses are those of loretin, which see.

W. A. Bastedo.

METHYL OXIDE.—Methyl oxide $(CH_3)_2O$, commonly called *methylic ether*, is the same compound of the radical *methyl* that common ether is of the radical *ethyl*. Methylic ether is a gaseous body at all ordinary temperatures (condensing only at a temperature of —21° C. [—5.8° F.]); is colorless, and of a not unpleasant ethereal odor. Methylic ether is a powerful and rapid anæsthetic, and was experimented with by Dr. B. W. Richardson, in 1867, with a view to its possible employment as an anæsthetic in surgery. Dr. Richardson used a saturated solution of methylic ether in absolute ethylic (common) ether, the solution being effected at the temperature of 0° C. (32° F.). The preparation, however, has never come into general use. *Edward Curtis.*

METHYL-PARA-AMIDO-META-OXYBENZOATE. See *Orthoform.*

METHYL-PHENACETIN, $(C_6H_4.OC_2H_5N.CH_3.CH_3CO)$, is phenacetin with a methyl group replacing the imide hydrogen atom. It is prepared by acting on phenacetin sodium with methyl iodide, and occurs in colorless crystals which are slightly soluble in water and readily soluble in alcohol. It resembles phenacetin in its antipyretic and sedative properties, but is said to be more hypnotic. Dose 0.12 to 0.7 gm. (gr. ij.–x.).

W. A. Bastedo.

METHYL-PHOSPHIN and *di-methyl-phosphin* have been used in malaria by Mannaberg with good results in dose of 1.2 gm. (gr. xx.) a day, but they have been found by Fürbringer to be powerful convulsant poisons which kill by paralysis of respiration. One-half gram per kilogram was fatal to rabbits. *W. A. Bastedo.*

METHYL-PYRIDIN SULFOCYANATE is a crystalline compound of chinolin and thiocyanic acid, which in one-per-cent. solution serves as a powerful non-caustic antiseptic. *W. A. Bastedo.*

METHYL-SALOL, para-cresotonic-phenyl ester, $C_6H_5.CH_3.OH.CH_3.CO_2$, occurs in colorless needle-like crystals,

insoluble in water and soluble in ether, chloroform, and hot alcohol. It is used as an antirheumatic in dose of 0.3 to 1 gm. (gr. v.-xv.). *W. A. Bastedo.*

METHYL-URETHANE, urethylane, $CONH_2OCH_3$, is prepared by acting on methyl alcohol with cyanogen chloride, and occurs in colorless crystals which are soluble in water and alcohol. It is used like urethane (ethyl urethane) as a hypnotic, which is not depressing to the heart. Dose 1 to 4 gm. (gr. xv.–ʒ i.).

W. A. Bastedo.

METHYLENE BICHLORIDE.—*Methylenic Chloride, Di-chloromethane*, CH_2Cl_2. This body is closely related to chloroform chemically, and, accordingly, much resembles that body in physical characteristics and in physiological properties. Methylene bichloride is a heavy, colorless, ethereal fluid, of specific gravity 1.344, and boiling point 40° C. (104° F.), and of neutral reaction. Its odor resembles that of chloroform. It mixes freely with chloroform, ether, and alcohol. The medicinal importance of methylene bichloride lies in the anæsthetic powers of the vapor of the drug, which closely resemble those of chloroform both in kind and in degree. This anæsthetic is one of Dr. B. W. Richardson's numerous proposed substitutes for chloroform, and has been quite extensively used by many surgeons, notably by Mr. Spencer Wells. The only possible advantage of this substance over chloroform would lie in greater safety; but since several deaths have unquestionably been caused by methylene bichloride, the anæsthetic must rank among the dangerous group. Dose and method of administration are substantially the same as those of chloroform, the only difference between the two bodies—so far as the mode of administration is concerned—being a lower boiling point, and therefore a higher volatility, in the case of methylene bichloride.

The name "methylene chloride" has been given also to certain anæsthetic mixtures—to a mixture of the present body and ordinary ether, and to one of chloroform and methyl chloride, or chloroform and methyl alcohol.

Edward Curtis.

METHYLENE BLUE (Tetramethylthionine Chloride). —An aniline derivative, its formula being $(C_6H_3N[CH_3]_2Cl)_2NS$. Chemically pure methylene blue occurs in small indigo-colored scaly crystals, with a bronze-like tinge and dark green in transverse fracture. It is slightly soluble in water, forming a deep blue solution, which is changed by sulphuric acid to a dark green, and from which a strong potash solution throws down a dark violet precipitate. The methylene blue of commerce (ethylene blue O) is a double chloride of zinc and tetramethylthionine.

This aniline product was introduced into medicine in 1890, by Drs. Ehrlich and Lippmann (*Deut. med. Woch.*, June, 1890), as an analgesic of some value. Professor Ehrlich had investigated the action of the drug on nervous tissue as a staining reagent, and had demonstrated that it had a peculiar selective action on the axis cylinders of motor and sensory nerves. Further experiments showed that when taken into the stomach, or introduced subcutaneously, it rapidly spread throughout the system and gave relief to all neurotic pains, and the pain in rheumatism of the muscles, joints, and tendons. A two-per-cent. solution was used, by means of which one grain was given hypodermically. It was also used in capsules, the powder being given in doses of gr. iss.-iv.; as much as gr. xv. were given in one day. No ill effects accompanied its administration, and there was no change in appetite, digestion, pulse, or any of the normal functions. The drug was absorbed very quickly, and a quarter of an hour after the smallest dose the urine became a bright green, after two hours a dark green, and after four hours a dark blue. In the saliva a bluish tinge was detected, but there was no discoloration of the mucous membranes or conjunctiva. Those observers found that the anodyne effect began in about two hours, and was gradually produced; it had no effect on any fever or inflammatory condition. Other observers have reported it of value in nervous headaches, herpes zoster, alcoholic depression, migraine, and in the pleuritic pains of tuberculous patients. Further use has failed to confirm this analgesic property and the drug is now rarely employed for this purpose; other compounds have proved more effective, and the discoloration which it produces renders its use objectionable.

In the following year (1891) Ehrlich and Guttman announced that the drug was also a remedy for malarial troubles. They were led to experiment upon this disease from the fact that the plasmodia of malarial disease were readily stained by this body, not only in prepared specimens but also in fresh blood. They used the remedy in two cases of malarial fever—one quotidian, the other tertiary. They found that it had a decided curative power over the disease; the periodical attacks ceased within a few days, and at the end of eight days all plasmodia had disappeared from the blood. A dose of gr. iss. was given ten or twelve hours before the expected attack, and repeated every two hours until five doses had been taken. The treatment, they say, should be continued for seven or eight days after all malarial symptoms have subsided. Other European observers have reported the results of a trial of this remedy, with more or less beneficial results. Laveran experimented with it without obtaining any success. He injected it into the blood of pigeons affected with the hæmatozoon, and although the color was seen in the blood no effect was exercised upon the parasites.

Dr. W. S. Thayer, in *Johns Hopkins Hospital Bulletin*, May, 1892, gives a detailed report of seven cases treated by this method. He concludes that: 1. Methylene blue has a definite action against malarial fever, accomplishing its end by destroying the specific organism; but it is materially less efficacious than quinine, failing to accomplish its purpose in many cases in which quinine acts satisfactorily. 2. Reaction appears to be rapid, the chills disappearing and the temperature, in remittent cases, falling to normal during the first four or five days; later, however, if a sufficient number of organisms have resisted the drug, they appear to develop again directly under its influence, causing a return of the symptoms. 3. Methylene blue seems to have no advantages over quinine which would warrant its further use. It is now recognized as a valuable remedy in the treatment of all forms of malaria, not replacing quinine, but of service in many cases in which this drug has failed, and the two together often succeeding when both have failed when given separately. The monograph of Dr. Cardamatis, of Greece, published in 1897 (*Deut. med. Woch.*, xxiv., 9) shows the remedy to be of decided value when given in doses of gr. x.-xij., commencing ten hours before the onset of the paroxysms.

A case of chyluria due to *Filaria sanguinis hominis* was reported by Austin Flint as cured by this treatment (*New York Medical Journal*, June 15th, 1895).

Methylene blue has also been given in tuberculous conditions. In pulmonary phthisis a dose of gr. iss. was given the first day, increased on the second day to gr. iij., on the third day to gr. ivss., and so on until gr. xxiv. were given in the twenty-four hours. The usual improvement of symptoms is said to follow its use. In tuberculous pharyngitis the powder may be applied to the affected part, and in scrofulous glands of the neck, and for irrigating empyemic cavities, a ten-per-cent. solution has been used. A solution of the same strength has also been recommended in diphtheria. It is reported that the drug has been employed with advantage as an injection in severe forms of dysentery.

The latest use of methylene blue has been in the treatment of diseases of the genito-urinary organs, both by internal administration and locally as an injection. It has been shown that as much as sixty-eight per cent. of the amount given is excreted by the kidneys, and during its passage it is mildly diuretic and exerts an anodyne and germicidal action. Numerous cases of kidney disease

have been reported in which it has proved beneficial, but it has been of most practical value in cystitis and urethritis, particularly when gonorrhœal in character. The dose is gr. i. three times a day, and oil of santalwood, copaiba, etc., may be combined. The bladder and urethra may also be irrigated freely with a solution of the strength of from half a grain to one grain to the pint.

Beaumont Small.

METHYLENE DI-TANNIN. See *Tannoform.*

METHYLENE DI-COTOIN. See *Fortoin.*

METHYL VIOLET. See *Pyoktanin.*

METRITIS.—DEFINITION.—Metritis is defined as an inflammation of the uterus, or, in other words, of the uterine wall. This definition, so far as it goes, is satisfactory, and if all of the conditions which are grouped under this head were inflammatory in their nature and always involved the whole of the uterine wall, there would be but little difficulty in giving a systematic account of the disease. As it is, however, many observers describe as a distinct entity diseases of the endometrium. This division necessitates another name when the muscular and connective-tissue portion of the uterine wall, or the mesometrium of Schultze, is involved, and it is to inflammatory or other changes of this portion of the uterus that the name metritis is often applied to distinguish it from endometritis. From the close relationship, however, which exists between these tissues and from the fact that recent observations show an almost constant involvement of some of the mesometrial tissue following primary inflammation in the endometrium, it is no longer proper to describe endometritis as a distinct disease. Therefore it is best to use the term metritis as meaning an inflammation of the uterus as a whole, while if special stress is to be laid on changes in one or the other part of the wall we may speak of an endometritis, or of a parenchymatous metritis, or of a mesometritis.

Further, we find grouped under the one head of metritis several conditions which are not in their nature inflammatory, but are the results of congestive or degenerative changes; and though these should properly not be classed under a term meaning in its derivation inflammatory, for the present, at least, until our understanding of the exact etiological factors is clearer, they must be grouped here, especially as it is difficult sharply to differentiate between the inflammatory and the congestive changes, and it is even more difficult to differentiate between the results of these two conditions in the later stages.

VARIETIES.—As in the definition of the term, so also in grouping the varieties do we find much confusion, and it is only necessary to review briefly some of the proposed methods of grouping to realize how difficult a matter it is to obtain a satisfactory conception of the whole. Thus we may divide the varieties, as does Winckel, according to their etiology. This is cumbersome, however, and leads to much obscurity. We may divide them according to clinical symptoms, and speak of endometritis hæmorrhagica, endometritis dysmenorrhœica, and endometritis catarrhalis. Or we may follow Ruge's classification, describing endometritis glandularis, endometritis interstitialis, and endometritis diffusa, to which Ruge adds three special forms, endometritis decidua, endometritis post abortum, and endometritis exfoliativa. This last is the classification most frequently used in this country and the one, with some modifications, which is employed here.

Acute Forms Involving both Endometrium and Mesometrium.

1. Acute puerperal metritis.
2. Acute septic metritis (non-puerperal).
3. "Metritis desiccans" Garrigues, or "gangræna uteri partialis post partum," Grammatikati.

Chronic Forms Involving Chiefly the Endometrium.

4. Endometritis glandularis.
5. Endometritis interstitialis.
6. Endometritis diffusa.
7. Endometritis exfoliativa.
8. Endometritis deciduæ.
9. Endometritis senilis.

Chronic Forms Involving Chiefly the Mesometrium.

10. Parenchymatous or interstitial metritis.

Conditions classed as metritides, in which there is no distinct pathological change.

11. "Metritis hysterica," Vedeler.

ETIOLOGY.—As etiological factors two main causes are found—bacterial infection and circulatory disturbances; although besides these two there are other influences which must be borne in mind, as, for instance, in cases of glandular metritis the clinical picture is of a hyperplastic change in the epithelium, and in this form we must search for some form of irritation. Again, for instance in the hysterical metritis, we must consider the cause as a local hyperæsthesia of the nerve terminals, and in fact in a number of cases of metritis we are forced to concede the fact that as yet but little is known of the etiology.

In studying more in detail the bacterial infections we find in the acute forms that the condition is a result of the attack of the pyogenic cocci. Thus, the most frequent variety of bacteria in cases of acute puerperal metritis is the streptococcus pyogenes, either alone or as one member of a mixed infection. This organism gains entrance to the uterine cavity through the widely opened cervix, and generally as a result of its introduction from outside through the medium of an unclean finger, speculum, forceps, or other instrument.

Acute septic metritis, not puerperal in origin, is less frequently recognized and is a rarer condition. As in the puerperal form, however, it is the result of the presence of one of the pyogenic cocci, probably most frequently the gonococcus, though various other forms have been isolated from the uterine cavity in these cases. The method of invasion varies. Most frequently, perhaps, the acute inflammation follows the introduction of a dirty sound or other instrument. The introduction of dirty instruments, or of an infected finger, into the vagina is also a means of infection, the micro-organisms reaching the cervix and gaining entrance to the uterine cavity through the cervical canal. In the same way a dirty pessary may be the means of spreading the infection. An acute gonorrhœal infection of the uterine wall usually begins some time during the menstrual period when the cervical canal is more widely open than usual, and when the organisms which have already attacked the cervix may be more easily carried into the uterine cavity by a back flow of the fluid blood.

Metritis desiccans is but one of the later stages in puerperal metritis, and is characterized by the destruction and sloughing off of large portions of the uterine wall.

As regards the more chronic forms, we must conceive in many cases a different course of events. A certain number of cases of chronic endometritis, especially the interstitial form, follow as a later result after the acute inflammation has subsided, there being in these cases a round-cell infiltration and a proliferation of the connective tissue with a possible change in the character of the epithelial cells which in places are found flattened or cuboidal and lying several layers in depth in place of the one layer of cylindrical cells. In many of the chronic cases the condition does not follow a bacterial infection at all, but is due to circulatory changes or to interference with uterine involution after delivery, and we may find the chief trouble either in the glandular tissue, in which case there are proliferative or degenerative changes in the glands, or it may be in the interstitial tissues in which it gives rise in the same way to active proliferation or degeneration; or, finally, we may find the chief effects of the circulatory disturbance in the mesometrial tissues,

the most marked change being a great increase in the connective tissue.

Theilhaber has carefully described an abnormal condition in the mesometrium which he thinks is the cause of many cases of endometritis. This change is chiefly in the muscle fibres, which are weakened, and for this reason there are not the usual rhythmical contraction and dilatation of the uterus which he considers to be always present normally, and as a result of this the venous circulation is not so rapid as it should be, and there result, naturally, congestion and dilatation of the venous trunks in the uterine wall. He considers this change in the muscle fibres due to too rapid growth, to degenerative changes such as are found in chlorosis, or to fibroid changes such as occur at the menopause. This theory at least accounts in a plausible manner for many changes in the uterus which we cannot otherwise explain.

To recapitulate briefly, we find, in the acute cases, that the etiological factor is always bacterial in its nature. In the chronic cases the condition may be due to bacterial infection, but it is probably more frequently the result of circulatory disturbances, or of subinvolution, or of some abnormality, or of degenerative changes in the uterine muscle.

Pathology.—In the acute puerperal metritis there is a varying pathological picture depending upon the grade of the infection. In the more common form, in which the infection has not extended through into the muscular walls, we find the superficial portion of the decidua more or less completely broken down, forming a disintegrated mass in which are seen clumps of bacteria and an occasional cell. Beyond these are still recognizable cells between which lie leucocytes and bacteria, and still deeper in the tissues is a wall of leucocytes beyond which the bacteria have not penetrated. In the more severe grades there is a more decided degree of necrosis of tissue, and masses of leucocytes are seen, instead of a distinct wall, while scattered through the tissue are bacteria lying in the lymphatics or small vessels, these being the foci for the abscesses found in the uterine wall in the later stages.

In acute septic and gonorrhœal metritis we sometimes find much the same changes as appear in the puerperal cases, there being a superficial necrosis of the mucous membrane with further invasion of the tissues by bacteria. Masses of leucocytes offer a barrier to this invasion, although this is not necessarily always the case, for sometimes small abscesses are found deep in the uterine wall, or the bacteria may extend through the lymphatics to the pelvic connective tissue or to the peritoneal surfaces. In less severe grades of acute metritis we do not notice such necrosis of the tissues, but find evidences of the acute disease in the filling of the lumina of the glands by masses of bacteria and leucocytes, and by the infiltration of the subepithelial connective tissue by leucocytes and newly formed round cells. In these cases there may be some infiltration of the deeper layers of muscle.

In the chronic forms of metritis there is a much more varied picture, depending upon the type of the disease. The interstitial form shows chiefly changes in the connective tissue between the glands, this tissue giving the impression of being denser and firmer than normal, due to an increase of connective tissue with necessarily a concomitant narrowing of the glands. On careful examination this increase is found to be due to the presence of spindle-shaped cells, which differentiate themselves sharply from the rather lightly staining cells of the normal subepithelial tissue. In the glandular forms we find, on the other hand, an increase in the number of the epithelial cells. There is a lengthening of the glands and they become extremely tortuous, with a lumen much wider than is normally the case, while the interstitial tissues show no change. Finally, we may have a combination of the two forms described above, in which there are changes both in the interstitial tissue and in the glands, giving rise to another type—endometritis diffusa.

Endometritis exfoliativa is characterized by the loosening and extrusion, at the menstrual period, of a complete or incomplete cast of the uterine cavity, this cast being composed of the mucous membrane and the underlying portions of the connective tissue.

Endometritis senilis is a result of the changed uterine conditions which follow the menopause, and is really a slow atrophy of the mucosa and submucosa. A section through the uterine wall of a well-marked case of this type shows either an absence or at least a flattening of the epithelial cells which are cuboidal in shape. There is an almost complete disappearance of the glands, and where they persist there is often an occlusion of the outer end, and a cystic enlargement from retention of the secretion. The submucosa is greatly thinned and the mesometrium is made up chiefly of dense connective tissue which has slowly taken the place of a portion of the muscle.

In parenchymatous metritis the most marked change takes place in the mesometrium, though the endometrium is always involved to some extent. The uterus feels firmer and harder than normal, and on section connective-tissue bands are seen in the wall. On microscopic examination the connective tissue is found to have extended between the muscle bundles, and in places appears to usurp entirely the place of the muscle. The vessels are large, especially the veins, and their walls are thickened and show signs of arterio-sclerotic change.

Symptomatology.—The symptoms of metritis vary greatly, according to the variety of the disease which may be present. Acute puerperal metritis appears usually within the first three days after delivery. As a rule it is ushered in by a chill accompanied by a sharp rise of temperature and an accompanying increase in the rapidity of the pulse. The patient feels bad, and headache, with perhaps nausea and vomiting, is complained of. The lochial discharge may not change in any way, though in many of the cases it is lessened, and it may become more serous in its nature. The presence or absence of odor depends upon the type of the micro-organism present or upon the amount of tissue destruction. Pain in cases of puerperal metritis is not a marked symptom, but when it is severe it should always cause a suspicion of peritoneal involvement. The course of such a case varies in accordance, apparently, with the virulence of the organism present. In many instances there is a direct extension of the infection to other tissues of the body; with death in the course of a few days. On the other hand, instead of a general infection we may find a severe local infection of the surrounding tissues with, for instance, local peritonitis, pelvic cellulitis, or pelvic phlebitis. In still other cases the leucocytes are able to cope with the infection and we find a distinctly local point of disease in the uterine wall, this being surrounded by a wall of leucocytes which prevents further invasion of the tissues. There may also be an extension of the disease into the tubes.

The symptoms of acute septic metritis are apt to be hidden by the frequent occurrence of tubal inflammation, which often accompanies it. In a case of pure metritis, however, a rise of temperature may be looked for soon after the use of a dirty sound, or, if the inflammation is of gonorrhœal origin, at the end of the menstrual period., At the same time there is apt to be a profuse discharge, rather thin and purulent in character, which possibly causes some local irritation. Besides this there is a feeling of general malaise, the patient complains of an aching in the lower abdomen, and there is a sensation of dragging on the pelvic viscera. On examining such a patient the abdomen will be found tense in the lower zone, tenderness on pressure is complained of, and on vaginal examination the uterus is found somewhat enlarged, soft, and very tender on palpation, the least movement of the uterus between the hands being accompanied by severe pain. If the speculum is introduced, a thin purulent discharge will be noticed welling out from the cervix, and if a sound is passed its withdrawal is followed by a little bloody discharge.

Metritis desiccans is characterized in the beginning by the same group of symptoms which occur in puerperal metritis. As the disease progresses, however, the dis-

charge becomes extremely foul in odor, is of a dirty yellowish or brownish color, and mixed with it are shreds and irregular pieces of the uterine wall which are soft and mushy in consistency.

The symptoms of the chronic forms may be taken up in a more general way, though in most of them one symptom predominates.

Pain.—This is a symptom which is present in most forms of metritis, although it varies greatly in character. In endometritis exfoliativa acute pain is always present during the menstrual period while the extrusion of the uterine cast is going on. Acute pain is also one of the chief symptoms in many cases of interstitial metritis, especially at the menstrual period. On the other hand, the pain, instead of being sharp in character, is more of a dull ache located deep in the pelvis or referred to the lower back or to the legs, and occurring most frequently at the menstrual time, though it may appear and be most severe in the intermenstrual epoch. Finally, some patients do not experience any real pain but complain of a feeling of weight or dragging in the pelvis; the sensation, as they describe it, is as if the pelvic organs were about to fall out.

Menstruation.—This is almost always changed in some way. Most frequently it is increased in amount, both the time during which the flow is present being prolonged and the amount of flow increased. There is frequently, also, some irregularity in the occurrence of the flow, the intervals between being usually shortened. This is true especially in the glandular forms of the disease or when the uterus is displaced backward. In the later stages, on the other hand, there is often a lessening of the menstrual flow with an increase in the length of the intermenstrual period.

Discharge.—Some discharge is almost invariably present in chronic metritis, though it is often masked by the discharge of a coincident cervical disease. The characteristic uterine discharge is thin, sero-purulent, or possibly blood-stained, and when the cervix is normal it may be noticed oozing out of the uterine canal. This discharge varies greatly in amount, sometimes being so free as to cause the patient much discomfort, while at other times it is so slight in amount as to be hardly noticeable; in fact, in some cases its existence can be ascertained only by careful examination.

General Symptoms.—Besides these local symptoms of metritis there are numberless others of which the patients complain. Some have violent occipital or vertical headaches, while others have vertigo or other nervous manifestations such as local anæsthesia or hyperæsthesia. The digestive tract is often involved, there being loss of appetite, slow digestion, intestinal flatus, or troublesome constipation. Anæmia is a common symptom and with it are frequently noticed cardiac palpitation, swelling of the ankles, or possibly dyspnœa on exertion, etc.

Diagnosis.—In a great majority of the cases the diagnosis is comparatively a simple matter, being based on the subjective symptoms and the result of the examination. The dull, aching sensation in the pelvis and back, with perhaps acute attacks of pain during the menstrual period, the uterine discharge differentiated from that coming from the cervix by its thin, watery character, the menstrual disturbances, and the general symptoms such as headache, etc., while not pathognomonic are, at least, when found together, very suggestive. If in addition to these it is found, as a result of bimanual examination, that there is enlargement or some change in the shape of the uterus, with uterine tenderness on palpation, and possibly slight bleeding, or acute pain if the uterine sound be passed, we have a symptom complex which in most cases admits of but little question. The difficult cases to diagnose are those in which one symptom alone is present or in which one symptom is so marked as to mask all the others. Among these stand, for instance, the cases of glandular endometritis in which the only symptom is profuse bleeding, and which must be differentiated from adeno-carcinoma of the uterine body, or from an intra-uterine polyp or small myoma. This can be done only by removing, for microscopic examination, some of the uterine mucosa. Another illustration is the "endometritis hysterica" of Vedeler, in which the only symptom is acute pain in the pelvis, which might be taken, on hasty examination, for inflammatory disease of the tubes or pelvic peritoneum, and which can be diagnosed only by a careful examination of the uterine cavity with a sound, demonstrating the existence of local tender points in the uterine wall. Finally, the possible presence of tuberculosis of the endometrium must always be borne in mind in making a diagnosis of metritis, as the symptoms of tuberculous disease here are always those found in other forms of metritis, and it is by the curette alone that we are able in many cases to decide whether or not tuberculosis is present.

Treatment.—*Prophylaxis.*—As has been seen, in considering the etiology, many cases of metritis are due to faulty involution of the uterus after delivery at term, or after a miscarriage, to displacement of the uterus or to disease of the cervix, to too frequent pregnancies, or to a markedly lowered condition of the general health; and if these factors were more carefully borne in mind by the general practitioner fewer cases of metritis would need later treatment. It is certainly easy to advise our patients to remain in bed after delivery or after a miscarriage longer than is usually done, and it is our duty to insist on this when the uterus is slow in returning to its normal size or when a bloody discharge lasts longer than is usual. Many displacements may be corrected by properly fitted pessaries, congestions or erosions of the cervix relieved by hot douches or other local measures, and advice given against the too frequent pregnancies which are so often seen.

General Treatment.—As the general health in most patients suffering from metritis is below par, much may be done by general treatment to relieve them. Many are anæmic, either as a result of profuse bleeding or because of the lowered general tone, and great benefit often follows the use of some easily assimilable form of iron, as, for instance, one or more of the Blaud's pills two or three times a day after meals, or, if this be not well borne, one of the albuminate of iron preparations is often satisfactory. The digestive troubles can be relieved by a carefully selected dietary, one of the simple bitter tonics being administered before the principal meals. The bowels are to be regulated by a proper selection of foods, or by one of the milder cathartics taken regularly for a time—as, for instance, small doses of the fluid extract of cascara sagrada, or one of the pills containing aloin, strychnine, and belladonna, with perhaps cascara or ipecac added. In addition to this, regular exercise is advisable, spending part of the day in the open air, with regular habits as regards rest, the time of meals, and the time of the bowel movements.

Local Treatment.—As a rule the first thing used is the time-honored tampon, and fortunately its use is often followed by relief if it be applied in properly selected cases, and especially if it be used in conjunction with hot douches. The cases in which the tampon is of the most service are those of interstitial endometritis and parenchymatous metritis. In these cases we have a large, heavy uterus, often somewhat displaced or tender on pressure, with possibly in addition a cervical erosion, or a large hypertrophied cervix. The tampon is made either of cotton or of lamb's wool, and is soaked in boroglyceride, or, as is sometimes advised, in a ten-per-cent. glycerin-ichthyol mixture. It is then carefully packed up against the cervix and into the vaginal fornices through a bivalve speculum. The tampon has a cord attached to it by which it may be withdrawn by the patient, and directions are given that it be removed at the end of twenty-four hours and a hot douche taken. These tampons are generally introduced two or three times a week, and in the interval the patient is advised to use a hot douche twice or three times during the twenty-four hours. Explicit directions must be given as to how the douches are to be used, as otherwise many patients will content themselves with sitting over a vessel and forcing the water into the

vagina, allowing it to run out immediately rather than to take the trouble of using it while in a recumbent posture.

Applications of various caustic or antiseptic substances to the uterine cavity were formerly much used, and the chloride of zinc and other like substances were applied in solution by means of cotton wrapped on an applicator, or by injecting it into the uterine cavity with a long-spouted syringe. This treatment is still sometimes advised, but it is unsatisfactory and may be dangerous, and, as a general rule, it has fallen into disrepute of late years.

Dilatation of the cervical canal and curetting of the uterine cavity probably constitute the most satisfactory method of treating metritis, the object being to remove the diseased mucous membrane and bring about a regeneration of this tissue, while at the same time the patient gets the good effect of an enforced rest in bed and the best chance is given for uterine involution to take place. Curetting should always be carried out with all proper antiseptic precautions, and the operation is much more easily and satisfactorily performed with the patient under general anæsthesia. As a rule, packing of the uterine cavity after curetting is advised against, and it should be an inflexible rule that such patients remain in bed for at least a week after the operation. Curetting may be performed at any time during the month, but, if it be practicable, the best time is about a week after the end of the menstrual period.

Another recent addition to our means of treating this disease is the local use of superheated steam, the method being known as *atmokausis.* This is carried out by introducing into the uterine cavity a suitably insulated tube connected with the proper form of kettle in which water is boiling. The steam is allowed to come into contact with the tissues for a varying length of time, depending upon the effect to be produced. It is, however, a dangerous method and, unless it is used under skilled directions, much harm may follow.

Finally, in some extreme cases of glandular endometritis in which curetting has given only temporary relief, and in which the patients are almost exsanguinated by the constantly occurring hemorrhages, removal of the uterus is the only means at our command for definitely controlling the symptoms. This should, however, be done only as a last resort when all other forms of treatment have been exhausted without relief to the patient.

Otto G. Ramsay.

METRORRHAGIA.—The ordinary or customary discharge of blood from the womb at the menstrual period is the point of departure, so to speak, from which this term originates. Just where to draw the line is difficult because the term is a relative one. What is ordinary and not excessive for one woman may be extraordinary and excessive for another. Any hemorrhage from the womb, be the quantity large or small, which depletes the woman's vital force may be regarded as metrorrhagia. The term menorrhagia is often used when this excessive loss occurs in connection with the monthly flow.

Metrorrhagia may therefore be regarded as a hemorrhage from the womb, excessive in quantity, occurring at no definite time, of no definite duration, and due to a variety of causes.

Conditions which favor or cause such a hemorrhage are relaxation of the uterine structures, hypertrophy of the uterine mucosa, malignant degeneration of the uterus, repeated congestion of the pelvic circulation, especially if the blood tension is high or the vascular walls are weak or friable.

1. *Relaxation of the Uterine Structures.*—Such a condition may signify merely a relaxed state of the uterine muscle, or relaxation of the mucosa as well. After a prolonged and severe parturition—especially if there has been uterine inertia during parturition, or if the patient has been kept under the influence of an anæsthetic for an unusually long time—the uterus frequently remains relaxed, the great uterine sinuses remain unclosed, and the blood may pour forth in a mighty current. This is commonly termed post-partum hemorrhage. It is a true metrorrhagia. The relaxed and flabby condition is often present in weak and anæmic women or in those who are suffering with serious disease, such as Bright's disease of the kidneys or tuberculosis. In such cases the hemorrhages are frequently profuse and of long duration. They may occur with the monthly period or during the interval and should be regarded with great seriousness, for such women cannot well sustain such losses of the vital fluid.

The treatment which I have found most effective for the first class of cases is the tamponade of the uterus in the presence of the hemorrhage. Other measures need not be discussed, for with me, at least, they have proved distinctly inferior to the tampon. My plan is to draw the uterus down to the vulva with a volsella firmly fixed in the anterior lip of the cervix, and then to carry successive portions of a long strip of aseptic gauze, two inches wide, quite to the fundus, with long narrow dressing forceps, until the cavity is fairly well filled, at the same time compressing the uterus with the left hand through the abdominal wall. In my hands this has several times proved efficient after other measures had failed. The same treatment is equally suitable for the profuse hemorrhage which often follows abortion. For the second class of cases one must first improve the general condition with iron, strychnine, and an abundance of food. In the intervals between the bleedings one may apply Churchill's tincture of iodine, or the nitrate of silver, four drachms to the ounce of water, to the endometrium every other day, and should such treatment be ineffective after a few weeks of trial, one may dilate the uterus and curette the endometrium. It may not be possible or desirable to scrape away much of the uterine mucosa, but the effect of the operation will be to stimulate the organ to contraction. The operation should be repeated if a single scraping proves insufficient. Some of the cases of profuse hemorrhage during the menopause are successfully treated by this method. The uterus is then tamponed, but not too firmly, the tampon being retained for two days.

2. *Hypertrophy of the Uterine Mucosa.*—The metrorrhagia which results from this cause may consist either of a continual dripping which requires the constant use of a napkin, or of a more or less profuse flowing which ceases only when the patient is exhausted or when the uterus is filled with a clot. The hypertrophied tissue is usually of rapid growth, contains an abundance of vessels, and breaks down readily. After it has broken down it is quickly renewed only to break down again and be accompanied by another hemorrhage. Such a condition frequently follows parturition at term, or abortion, especially if the entire product of conception were not expelled or removed. It also results from gonorrhœa which may have invaded the endometrium, from the presence of fibromyomata within the uterine muscle, especially when their development is toward the endometrium rather than toward the peritoneum, and it not infrequently is one of the phenomena which accompany the menopause. The treatment in all these conditions is the same, for the pathological significance is the same in all. To attempt to relieve the hemorrhage by the internal use of drugs is futile and an unreasonable waste of time. Even the use of astringent or caustic applications to the endometrium is of doubtful value, and in most cases will only prove disappointing and unsuccessful. The only excuse for such treatment would be the unwillingness of the patient to submit at once to the operative method. This consists in the careful and sufficient dilatation of the uterine canal and the removal, with a sharp curette, of the entire hypertrophied mucous membrane. The uterine cavity is then tamponed with aseptic gauze which may usually be retained for two days. In almost all cases the result of this operation will be the immediate cessation of the hemorrhage, and very frequently the cure will be a permanent one. If, however, the cause of the bleeding is a fibromyoma the bleeding will probably recur, and it may be necessary to remove the tumor to produce a permanent

result. A repetition of the operation is also frequently required in connection with the menopause.

3. *Malignant Degeneration of the Uterus.*—Any form of malignant degeneration of the uterus is likely to be accompanied by metrorrhagia. In the case of sarcoma the bleeding is not so frequent and may not be so profuse as in that of carcinoma. Whether carcinoma be limited to the cervix or to the corpus, or involve both parts of the organ, hemorrhage will invariably occur. It may occur as a result of great emotion or excitement; it often occurs after coitus. The slightest disturbance of the friable tissue of the cancerous uterus causes bleeding which may be very difficult to arrest. If the diseased tissue is not disturbed in any way there will be a periodical disintegration and breaking down of such tissue, accompanied by profuse hemorrhage. The hemorrhage usually comes with a gush and continues until the patient is exhausted, until a sufficiently large clot is formed, or until it is arrested by mechanical means. The treatment of such hemorrhages is of course only palliative, in so far as the disease which causes them is concerned. For the immediate arrest of the bleeding, pledgets of cotton wool saturated with a solution of alum or of persulphate of iron should be carefully introduced, one after the other, into the vagina, until that cavity is firmly packed. This packing may be left undisturbed for twenty-four hours, and then, if the bleeding recurs when it is removed, the same procedure should be repeated. As soon as possible it is desirable that the diseased tissue should all be scraped away with the sharp curette and a tampon introduced like that which has been described. Such an operation is usually followed by relief from hemorrhage, perhaps for weeks or even months.

4. *Repeated Congestion of the Pelvic Circulation.* Hemorrhage from this cause is of frequent occurrence, and there may or may not be any apparent hypertrophy of the uterine mucosa. It may be the result of excessive sexual indulgence, of great emotion or excitement, of sudden removal to a great altitude where the atmospheric pressure is decidedly lower than the pressure within the blood-vessels, or of unusual blood tension from a variety of causes at the time of the monthly flow. I have frequently seen this variety of metrorrhagia in prostitutes and I believe that it is very common with them, especially if they are also suffering with disease of the tubes and ovaries, to which they are very susceptible. Hysterical women or women who experience great calamities or catastrophes are sometimes sufferers from this form of hemorrhage. Women who remove their residence from the sea level to an altitude of six thousand feet or more are frequently troubled with metrorrhagia until they become accustomed to their new surroundings, even though they may be in ordinary health in all other respects. Those who suffer from this cause at the time of the monthly flow may not present any lesion which is discoverable as a cause. Metrorrhagia sometimes occurs upon the approach of the menopause. The condition will usually yield quite readily to treatment. It is hardly necessary to say that if the cause is excessive coitus such excess should cease. Those who reside in high altitudes should change their residence if the bleeding does not cease after a few months. The hysterical and emotional must learn self-control, and if the blood tension is excessive a course of treatment with the bromides must be entered upon. In some cases it may be desirable to make applications of iodine or carbolic acid or persulphate of iron to the endometrium, and if this does not avail it will be necessary to dilate the uterine canal and curette the endometrium. For the immediate treatment of the hemorrhage the tamponade of the vagina after the manner which has been described will usually prove effective.

Andrew F. Currier.

MEXICO.—This great southern portion of North America, extending over seventeen degrees of latitude and thirty of longitude, is comprehended between the United States and Central America on the north and south, and the Pacific Ocean and the Gulf of Mexico on the east and west. It is 1,950 miles long and 750 wide in the widest part, and 140 in the narrowest. It has an area of 767,005 square miles, and almost equals Great Britain and Ireland, France, Germany, and Austria-Hungary together. Mexico is a republic (largely modelled on that of the United States) containing twenty-seven states and one federal district. Its population is 13,545,462. It consists principally of an immense tableland or plateau, averaging 8,000 feet in height at the southern portion in the states of Mexico and Puebla, and thence northward it falls in height to 3,600 feet at El Paso Del Norte. The boundaries of this plateau are formed by the Sierra Madre—an almost unbroken chain—on the west; and on the east, parallel to the Gulf Coast and from ten to one hundred miles from it, by the Sierras of the east, forming more a series of groups than a connected range. There are also short cross ridges which break up the surface, the principal one being the Cordillera de Anahuac. Outside of these mountain boundaries the land slopes to the Gulf and to the Pacific, quite gradually on the east, while on the Pacific side the Cordillera runs on the whole very near the coast, leaving a very narrow strip of land between the same and the sea. "All climates," as Hann remarks, "are represented in Mexico—the hot, damp climate of the tropics, as well as the hot dry desert climate of the lowlands. The temperate climate of the medium elevations, and the climate of the region of eternal snows on the highest mountain peaks." This relief of the land—its varying elevation—rather than the latitude, determines the diversity of the climate.

Three different climatic zones are distinguished. *First,* the *warm*—*Tierra Caliente*—up to about 3,000 feet. This is considered a hot, damp, unwholesome region as a whole, especially the low marshy Gulf coast, where various diseases are prevalent—malaria, yellow fever, dysentery, and others. The temperature varies from 77° to 82° F.; it seldom falls below 60° and often rises to 100° or more. In the coast valleys, however, at an altitude of from 500 to 3,000 feet, the climatic conditions are improved, and malaria is much less prevalent. These valleys "blossom" throughout the year and are well sheltered by the mountains, so that neither extreme heat nor uncomfortable cold prevails. At Vera Cruz, one of the principal ports on the Gulf, yellow fever is exceedingly prevalent, and Wells refers to the great mortality of American consuls there ("Mexico," David A. Wells). *Second,* the temperate zone—*Tierra Templada*—embracing territory from 3,000 to 5,000 or 6,000 feet in altitude. The climate in this region is that of continual spring, the mean annual temperature being 62° to 70° F., varying but a few degrees during the season. This zone embraces all the higher terraces and portions of the central plateau. "The zone of temperate lands, oceanic slopes," says Romero ("Geographical and Statistical Notes on Mexico," M. Romero, 1898), "enjoys an everlasting spring, being exposed neither to severe winter nor to intolerable summer heats; in every glen flows a rippling stream; every human abode is embowered in leafy vegetation, and here the native plants are intermingled with those of Europe and Africa. Each traveller in his turn describes the valley in which he has tarried longest as the loveliest in the world; nowhere else do the snowy crests or smoking volcanic cones rise in more imposing grandeur above the surrounding sea of verdure all carpeted with the brightest flowers." Chihuahua, elevation about 4,500 feet, may be taken as a type of the climate of the central plateau lying in this zone. The coldest months are from November to February, and the hottest from May to August. The summer climate is very agreeable and the air cool and bracing. According to Hinsdale ("A System of Physiological Therapeutics, Climatology, Health Resorts," vol. iv., book ii., p. 219), yellow fever, dysentery, and diarrhœa are frequent causes of death in this zone, while, on the contrary, it is stated in the article on Mexico in the Encyclopedia Britannica, that endemic fevers cease altogether at an elevation of 2,700 and 2,800 feet. *Third,* the *cold* zone—*Tierra Fria*—embracing territory of an elevation of from 5,000 or 6,000 to 8,000 and 9,000 feet.

This zone includes all the higher regions of the central plateau, and Zacatecas is the gateway to it from the north. In this zone (cold) are situated some of the most important cities of Mexico, such as Aguas Calientes, San Luis Potosi, Leon, Lagos, Silio, Queretaro, Guadalajara, and Mexico City. The mean average annual temperature is from 59° to 63° F., and the rainfall is about five times less than in the temperate zone. It is in this cold zone that the most favorable climatic conditions exist for the open-air treatment of tuberculosis, if one were sure of obtaining good accommodations, good food, and efficient medical service. "In this higher plateau, the climate," says Squires (*Medical Record*, 1897, vol. lii., p. 782), "is an ideal one both winter and summer, and is rendered even and temperate by the shelter afforded by the mountains from the winds and storms. December and January are the coldest months, but the thermometer rarely reaches freezing. The days are delightful, and every day is clear and bright, and flowers are in bloom." "If possible," continues Squires, "the summer climate on this plateau is superior to that of winter; rain begins in June and continues until October. (South of latitude 28° N. there are but two seasons, the rainy and dry.) It rarely rains, however, more than two or three hours a day, in the afternoon. At this season the vegetation is luxuriant. The nights are always cool." Squires thus describes a day during the rainy season:

"One is awakened in the morning by the sunshine pouring into his room. The birds in the patio of the hotel as well as those in the gardens are singing. The fragrance of the moist ground and flowers comes into the open window with the sunshine, and aside from the clear moist air one would not realize that it had rained the day before and that it was a morning in the height of the rainy season. It seems too beautiful to remain longer in the house, and one is soon up and out into the bright sunlight. The sky is cloudless except for a little bunch of clouds near the horizon, and as the day wears on this grows larger, until by three or four o'clock in the afternoon the sun is hidden and the rain commences. Shower follows shower for two or three hours, and then the clouds disappear, and by seven in the evening the streets are dry, the moon shines out, and then the population of the town comes to take a walk and sit on the plaza, and listen to the music. One can stay there until midnight if he chooses without fear of cold or catarrh."

The following table gives some of the principal climatic data of various points in this region as well as of Monterey in the warm zone, and of Jalapa and Oaxaca in the temperate:

low humidity, small precipitation, and an equable, mild temperature with comparatively small variation throughout the year. There are also absence of snow, and protection from wind and dust. Naturally, then, such a climate should be well adapted for the open-air treatment of suitable cases of pulmonary tuberculosis, if one were sure of proper accommodations and food and efficient medical service. When these are assured, this region would seem destined to become a great and popular health resort. Perhaps, however, its greatest value will be in offering a permanent residence to those who are phthisically inclined, or who for any reason cannot comfortably endure the rigorous climate of the North with its indoor life. The opportunities for business or life on the land appear to be increasing with the development of the country under President Diaz.

According to Squires (*loc. cit.*) asthmatics find relief in this climate, and those affected with Bright's disease, without cardiac complications, experience some relief from the disease. It is favorable also for neurasthenia and insomnia. Those suffering from organic heart disease should not visit this or any other elevated region. The invalid should exercise here the precaution necessary in approaching all elevated regions, namely, to make the ascent gradually and refrain from violent exercise for some days until the circulation recovers its equilibrium.

The vegetation of Mexico is extraordinary as regards both its variety and its luxuriance. Tropical, semi-tropical, and the temperate-zone products are found at the varying elevations. In the so-called "paradise" of Mexico, the temperate-zone region, especially on the terrace facing the gulf, "a wealth of semi-tropical vegetation" is found. "No country in the world shows so many variations in the aspect of plant life as Mexico" ("The Universal Encyclopædia"). "The tropical flora invades many parts of the terrace lands and even of the plateaus to heights of 4,000 and 5,000 feet." To enumerate some of the plants and fruits—there are the orange, lemon, olive, mango, pomegranate, pineapple, banana, ginger, coffee plant, cotton, sugar cane, india-rubber tree, cocoa, almond, rice, vine, maize, wheat, tobacco, yucca, an endless variety of the cactus family, the palm, the maguey from which pulque is made, the cypress, oak, pine, fir, and cedar, and an infinite variety of plants and flowers. There are one hundred and fourteen different species of building timber and cabinet wood, and fifty-nine classified species of medicinal plants.

A short description will now be given of some of the more important places of resort in the plateau.

City of Mexico: (elevation 7,472 feet; population 347,-

METEOROLOGICAL OBSERVATIONS (ANNUAL AVERAGES). (TAKEN IN VARIOUS CITIES OF MEXICO DURING SEVERAL YEARS.)

From M. Romero, prepared by the Meteorological Observatory of the City of Mexico.

Localities.	North latitude.	Height above sea level. Feet.	Temperature.			Relative humidity. Per cent.	Average clouds.	Wind.		Rainfall. Inches.
			Maximum.	Minimum.	Mean.			Prevailing direction.	Velocity.	
Mexico	19.26	7,472	88.8° F.	29.0° F.	60.0° F.	60	5.0	N. W.	0.8	23.9
Zacatecas	22.46	8,174	71.2	43.0	55.7	48	3.2	S. E.	2.6	32.0
Guadalajara	20.41	5,131	95.9	23.9	67.4	53	No. of cloudy days, 124.	N. E.	2.4	33.6
Monterey	25.4	1,610	91.7	53.0	69.8	60	Days of rain, 94.	S. E.	....	24.5
Saltillo	25.25	5,307	93.2	27.0	62.2	61	4.4	N.	1.4	20.5
Durango	24.2	6,500	88.0	20.0	62.0	..	....	......	....	21.5
Aguas Calientes	21.53	6,086	84.3	37.0	65.4	53	....	N.	....	21.1
San Luis Potosi	22.9	6,190	93.0	28.8	63.3	60	4.4	E.	1.3	15.1
Silao	20.56	6,053	90.0	39.2	67.1	..	Days of rain, 99.	W.	....	13.5
Puebla	19.03	7,106	89.4	30.0	60.2	63	4.7	N. E.	1.9	36.1
Queretaro	20.45	6,060	91.5	33.8	64.5	59	4.1	E.	.6	23.5
Jalapa *	19.32	4,712	92.3	42.9	65.3	..	Days of rain, 202			
Oaxaca	16.57	5,092	91.2	43.2	69.0	80				

* Within the belt of one hundred inches annual rainfall.

The whole of the great central tableland—the great plateau of Anahuac—possesses an unsurpassed all-the-year-round climate; it has elevation, abundant sunshine,

000), situated upon the Anahuac Plateau, in the western portion of a great valley, surrounded on all sides by high mountains, with the two snow-capped volcanoes—Popo-

catapetl and Ixtachihuatl—rising up like watch towers over the valley, wrapped about with an extraordinarily clear atmosphere, and enroofed with a marvellously blue sky, stands the capital of the great republic of Mexico amidst imposing scenery, full of historic interest and suggestion. If the traveller has never done so before, he should not leave this memorable city without reading Prescott's fascinating and graphic description of that wellnigh incredible feat, the conquest of Mexico by Cortez, of which the capture of this city was the culmination. Round about the city are six lakes, two of which are sweet waters and the others salt. The near presence of these bodies of water is not particularly favorable from a health point of view, and has made the problem of adequate drainage difficult. The city itself is imposing in its extent and regularity; in its public buildings, churches, and cathedral, its public squares and avenues, and in its scientific and literary establishments. Water is brought into the city by two stone aqueducts leading to a great number of fountains from which the water is distributed in earthen jars by water carriers. The whole valley in which the city is situated is now drained by a tunnel (six miles long, extending through the mountains) and a canal, the total length of the two combined being nearly thirty-seven miles. With this canal and tunnel the city is being connected by a new and complete sewerage system. "When this is completed"—as it nearly is —"the city of Mexico will be one of the cleanest, healthiest, and prettiest cities in the world" (Hon. John W. Foster, the *National Geographic Magazine*, January, 1902). The climate is temperate and delightful. The mean annual temperature is 60° F., the maximum 88.8° F., and the minimum 29° F.

The temperature of Mexico City for July is as follows:

Monthly mean in shade	62.96° F.
Monthly mean in sun	63.14
Maximum in shade	77.18
Maximum in sun	88.34
Minimum in shade	53.60
Minimum in open air	46.40
Total range in shade	23.58
Total range in open air	41.94

The nights and mornings are cool and agreeable the year through, although occasionally in January and February the thermometer sinks to the freezing point in the mornings. The warmest months are April and May, and the coldest December and January. The rainy season lasts from May to October; there are one hundred and thirty-nine rainy days, and the annual precipitation is 23.9 inches. The mean annual relative humidity is 60 per cent.; it is the least in spring, 49 per cent., and the greatest in September, 72 per cent. Heretofore Mexico has not been a healthy city owing to the lack of proper drainage and the habits of the poor classes. Intestinal diseases are the most common and fatal; typhus fever, rheumatic fever, tuberculosis, and smallpox among the Indians, are also prevalent. Malaria is common, and, in the higher elevations in general, pneumonia is a much dreaded disease, and a very large per cent. of the cases are quickly fatal. According to Galloway, nasal catarrh is very prevalent among the Americans ("Experience of an American Physician in Mexico," D. H. Galloway, *Journal American Medical Association*, 1895, vol. xxiv., p. 119).

From Mexico City many attractive excursions can be made to the Castle of Chapultepec, Guadalupe Hidalgo, Toluca, and other points of interest. There are a number of good hotels and restaurants in the city, and an extensive system of tramcars. French, English, and Spanish are spoken in the hotels and shops.

Guadalajara, 5,131 feet above the level of the sea, has a population of 83,934 inhabitants. It is called the "Pearl of the Occident," and is said to be one of the best lighted and cleanest cities of Mexico. Here is a fine cathedral, the largest theatre in the republic, a famous hospicio, and many fine parks and gardens. According to Solly ("Medical Climatology") Guadalajara is well supplied with restaurants and hotels, and the drainage and sanitary conditions are superior to those of most Mexican towns.

The climate is fine, partaking of the characteristics of all this plateau. The mean annual temperature is 67° F. with a maximum of 95.9° F. and a minimum of 23.9° F. In winter there is an average of twenty-five cloudy days. Forty miles south of Guadalajara is Lake Chapala, 6,000 feet above the sea. It is fifty miles long and eighteen wide, and is the largest lake in the republic. Fifteen miles east of the city are the Falls of Juanacatlan, called the "Mexican Niagara." The excursion to San Pedro, a favorite and wealthy suburb of the city, is very attractive, as are many other excursions round about the city.

Queretaro—elevation 6,060 feet—contains about 47,000 inhabitants and is beautifully situated in a fertile valley with the mountains in the distant background. It is said to be one of the most beautiful cities in Mexico. The streets are narrow and crooked but generally neat and clean. There are many attractive old churches, numerous public fountains, and handsome plazas. A stone aqueduct, five miles long and of attractive architecture, brings water into the city. Two miles out of the city is the spot where the Archduke Maximilian was shot in 1867. The climate of Queretaro is much like that of Guadalajara, the annual average temperature being 64.5° F.; the maximum 91.5°, and minimum 33.8°. In 1894 the seasonal temperature was as follows: winter, 59° F.; spring, 69°; summer, 68°; autumn, 62°. The monthly mean for January was 60°, and for May (the warmest month), 72°; for July, 67° (Solly).

San Luis Potosi—elevation 6,190 feet, population about 75,000—an enterprising business city called "the Chicago of Mexico." It is situated in a fertile region surrounded by mountains. The climate is very much like that of Queretara, the mean annual temperature being 63.3° F. San Luis Potosi is in a region of rich silver mines, and has the largest smelting plant in Mexico. The drainage is said to be poor, but the streets are clean. There are a government palace, a cathedral, plazas, and an attractive alameda.

Saltillo—elevation 5,307 feet, population 20,000. This city possesses an excellent all-the-year-round climate. The mean annual temperature is from 62° to 64° F.; the maximum 93.2° F., and the minimum 27° F. The number of rainy days is sixty-six yearly. There is a good water supply from the mountains. In the parks flourish, throughout the year, the lemon and orange trees, the oleander, rose, violet, geranium, and other plants of a semi-tropical nature. The climate of this place is said to be favorable for persons suffering from malaria, or from nervous maladies, and for weakly individuals. Saltillo possesses warm sulphur springs, and there are two hotels.

Durango—elevation 6,500 feet, population about 30,000 —is situated in the plain of San Antonio, and possesses a mild, dry climate, with a mean winter temperature of about 50° F., and an annual mean temperature of 62° F. There is an abundant supply of pure water, but no good system of drainage. The streets are well shaded, and the plazas are attractive, with flowers in bloom the whole year. According to Hinsdale ("A System of Physiological Therapeutics," vol. iv., book ii., Climatology, p. 322) it is an excellent place for the *tuberculous*, but there is but one hotel in the town and the prices there are excessive.

Zacatecas—elevation 8,174 feet; population 50,000. This is a mining town of ancient date, picturesquely situated in a mountain ravine, and is one of the highest points in Mexico. On account of its great elevation the climate is cool, very dry, and stimulating. The mean annual temperature is 55.7° F.; the maximum 71.2° F., and the minimum 43° F.; the average relative humidity is 48 per cent. Tuberculosis is said to be very rare there.

Aguas Calientes—6,086 feet above sea level, a city of 30,000 or more inhabitants—has a fine climate the year round, and, according to Squires, the hotels are exceptionally good. The hot baths are a great attraction, and there are well-appointed bathhouses with arrangements for shower baths, and large swimming tanks.

These baths are much frequented and are serviceable for rheumatism, skin, and nervous diseases. There are many fine gardens and several plazas here. In the month of April is held the annual fair (the Feast of San Marcos), which attracts people from all over the republic. This city is on the line of the Mexican Central Railway, and is also connected with Tampico by rail.

Silao—elevation 6,053 feet; population, 15,000. This is an attractive town with handsome gardens and some fine churches, possessing a climate very similar to that of Guadalajara. The mean annual temperature is 67.1° F.; the maximum 90° F., and the minimum 39.2° F. According to Hinsdale (*loc. cit.*) there is a sanatorium here under good medical direction.

Puebla—elevation 7,106 feet; population 88,000. This large city, one hundred and fifteen miles southeast from the city of Mexico, is beautifully situated in the midst of a well-wooded and fertile district, near the snow-capped mountains, and is said to be one of the cleanest and best-drained cities in Mexico. The streets are broad; there are several plazas, and the cathedral vies in richness and beauty with that in the city of Mexico (Solly). The climatic data are similar to those for the city of Mexico, except that its greater nearness to the snow-covered mountain peaks renders the nights cooler. Seven miles from Puebla is the great and famous pyramid of Cholula.

Many other cities might be mentioned, such as Guanajuato, Leon, Morelia, Patzcuaro, Chihuahua, Monterey, and others, but it would be, in a measure, but a repetition, as the general characteristics of all these Mexican towns are quite similar, and in their climate they differ one from another principally in the difference of the climate of the so-called "temperate" and "cold" zones.

There are also many mineral springs of value in various portions of the country. Some have already been mentioned, others are at Santa Rosalia, a town of about 8,000 inhabitants, where there are sulphur springs with accommodations which are said to be good. Near Mexico City, at Guadalupe, are the Penon baths and wells, which are said to compare favorably with Kissingen, Wiesbaden, Wildbad, and Ems; there is a hotel with modern conveniences and bathhouses "complete in every particular." Four miles distant from Monterey are the Topo Chico hot springs with an excellent bathhouse conducted by an American. At Comaujilla, near Monterey, are others.

The Mexican Central Railway traverses the great central plateau from El Paso in New Mexico to Mexico City, and to Tampico on the Gulf Coast, thus affording easy access to most of the large cities in this region. Other places are reached by the Mexican International, National, and other railways. Excellent excursions with first-class accommodations afford opportunities, during the winter and spring, for making the Mexican tour. One can also reach Mexico by water to Tampico and Vera Cruz, and thence by rail to Mexico City. *Edward O. Otis.*

MEZEREON.—MEZEREUM. The barks of several species of *Daphne* are collected and sold under the above names; thus the United States Pharmacopœia admits "*D. Mezereum* L. and other species"; the British Pharmacopœia "*D. Mezereum, D. Laureola,* and *D. Gnidium* L." The French Codex restricts the name properly to the first-named species, but also recognizes *D. Gnidium* L. as *Garou ou Sainbois.* The genus is essentially of European and Asiatic origin, and comprises about forty species of trees and shrubs, with tough, irritating, and acrid bark, and generally evergreen leaves, and pretty, usually fragrant, flowers. Several species are cultivated as ornamental shrubs.

Mezereon bark is collected in winter, and imported in rolls or bundles; often it is pressed irregularly into bales. It is prepared for the market in the form of long, very tough strips which curl inward on drying. Externally, it is smooth, grayish, or reddish-brown with transverse scars and minute blackish dots. Underneath the corky layer it is bright green. Internally, it is whitish and silky. The corky and bast layers are easily separable; odor slight (when dry), taste very acrid. The fresh bark is actively irritant to the skin, and may be used as a vesicant. The dried bark moistened, or a decoction made from it, has the same qualities. Owing to this irritating quality it is made abroad into liniments and ointments.

COMPOSITION.—*Mezereum resin,* a yellowish-brown, shining, non-crystalline substance of sharp, burning taste, and very irritating action upon the nasal mucous membranes and skin, is the irritating constituent. *Daphnin* is a crytalline, bitter, neutral glucoside, not important.

ACTION AND USE.—Of the irritating character of the bark, due to the above-named resin, and its application in blistering fomentations, liniments, etc., perhaps enough has been said. It is not so desirable for use, in this country at least, as several better known and more reliable rubefacients—ginger, for instance, or cantharides. Internally it has been given in chronic rheumatism, in syphilis, "scrofula," etc., with no definite reason and no advantage. In overdoses it is a gastro-intestinal irritant poison.

ADMINISTRATION.—Pieces of the bark soaked in vinegar are sometimes used as slow blisters. For internal use the dose of the bark is, say, 0.5 gm. or a little more; it is very seldom given alone. Our official preparations are: Compound Decoction, and Compound Extract of Sarsaparilla, and the Fluid Extract of Mezereon. An extract also was formerly official, but was dropped because its use became obsolete in this country.

W. P. Bolles.

MICROCIDIN.—An antiseptic preparation introduced by Dr. Berlioz, of Grenoble, which is prepared by adding to fused naphthol-beta half its weight of caustic soda and allowing the mixture to cool. It should contain seventy-five per cent. of naphthalate of soda, the remainder consisting of mixed naphthol and phenol compounds. It is a whitish powder, soluble in three times its weight of water, yielding a brownish solution. It is a powerful antiseptic, very slightly toxic, is not caustic, and does not injure instruments or clothes. It is said to be ten times more powerful than phenol, and twenty times more powerful than boric acid. A solution of three parts to the thousand is used as a lotion and to prepare dressings. A solution of the same strength may be used for irrigating the bladder, uterus, and suppurating cavities.

It may be employed as an internal remedy in doses as high as thirty grains a day. It does not produce any irritating effect. The urine is rendered strongly antiputrescent, its action being similar to that of salol, but less irritating to the kidneys. *Beaumont Small.*

MICRO-ORGANISMS: TECHNOLOGY. See THE APPENDIX.

MIDDLETOWN MINERAL SPRINGS. — Rutland County, Vermont.

POST-OFFICE.—Middletown Springs. Hotel.

ACCESS.—Viâ Delaware and Hudson Railroad to Poultney; thence a short drive by stage to springs. The location is fourteen miles from Rutland (where tally-ho stage also meets train during the season) and seventy-five miles north of Troy, N. Y. This charming resort is located 3,000 feet above tide-water, on the westerly slope of the Green Mountains. Both nature and art have done much to render it a delightful summer resting-place. The high elevation is a guarantee of pure, wholesome air and absence from many of the common insect pests. The Hotel Montvert is said to be the largest building of this kind in the State, having accommodations for three hundred and fifty guests. The appointments are of a high order of excellence. Large and airy rooms, breezy halls, and broad piazzas contribute to the comfort of the guests. There are also a handsome billiard room and a bowling alley. From the piazza a fine view can be had of many of the well-known Green Mountain peaks. Connected with the hotel is a beautiful park of fifty acres, artistically laid

out in lawns and walks, with enticing shady nooks on every hand. Ample provision is made for the wants or children, young people, and lovers of croquet, tennis, and other outdoor games. The surface of the ground in the neighborhood is formed of hard limestone rock natural to the country, which gives the roads a macadamized smoothness. This fact renders the country very attractive to bicyclists. The roads are lined with shade trees, and wayside springs are found at frequent intervals. There are also ample resources for fishermen and the lovers of horseflesh and amateur photography. The springs are situated on the hotel grounds, near the north bank of the Poultney River. Around the springs is a beautiful grove of shade trees, with pleasant walks, garden chairs, and settees. The springs have been used by white men since 1811, and, according to tradition, for an untold prior period by the aborigines. An analysis was made some years ago by Peter Collier, at that time analytical chemist of the University of Vermont:

ONE UNITED STATES GALLON CONTAINS:

Solids.	Grains.
Calcium sulphate	0.12
Calcium carbonate	2.80
Magnesium carbonate	1.05
Iron carbonate	1.11
Manganesium	.98
Aluminum	.07
Potassium chloride	1.08
Sodium chloride	.18
Sodium carbonate	2.68
Total	10.07

This water is highly recommended in cases of gout, rheumatism, anæmia, dyspepsia, and general debility. The water of the "Montvert" Spring supplied to the guests of the hotel is not, strictly speaking, a mineral water. An analysis by Professor Doremus, of New York, showed the presence of a trace of iron. It is slightly acidulous and very palatable, and possesses the qualities of an excellent table water. It is bottled and sold by druggists and grocers. *James K. Crook.*

MIDWAY WARM SPRINGS.—Wahsatch County, Utah.

POST-OFFICE.—Midway. Accommodations for fifty visitors.

ACCESS.—From Salt Lake City viâ Utah Central Railroad to Park City, and thence by stage to springs. The location of these springs is in a valley about eight miles square, surrounded by mountains. The altitude of the resort is about 5,500 feet above the sea level. The temperature of the region varies from 85° F. in summer to 25° F. during the winter months. We are informed by Mr. Thomas Monks, who owns one of the largest springs, that the water deposits a large proportion of its solid contents as it flows. The constant accumulation of this deposit, which is calcic in character, has led to the formation, around the springs, of natural basins which are known as "pots" among the settlers. Some of these pots or basins have attained a great height, the one owned by Mr. Monks having an altitude of 90 feet and a diameter of 200 feet across the top. Some of these natural reservoirs have become entirely dry, while others have standing water in them, with no apparent outlet. The pots are about thirty in number. The flowing springs yield from three hundred to twelve hundred gallons per hour. The water ranges in temperature in the different springs from 85° to 112° F. An analysis of one of the springs by Dr. A. Meacham, of Salt Lake City, showed the following mineral ingredients:

ONE UNITED STATES GALLON CONTAINS:

Solids.	Grains.
Sodium chloride	19.81
Sodium carbonate	1.54
Calcium carbonate	58.18
Magnesium carbonate	5.32
Iron carbonate	1.05
Magnesium sulphate	3.57
Calcium sulphate	6.83
Sodium sulphate	3.15
Aluminum sulphate	.56
Silica	2.73
Potassium compounds	Traces.
Nitrogen	Traces.
Total	102.74

Carbonic acid gas, considerable quantities.

This analysis shows a fairly strong alkaline-saline water. It should possess the properties of a mild saline cathartic and diuretic when taken internally. It also contains sufficient iron to give it some tonic influence. The springs are resorted to by the settlers to some extent, but no studies of their therapeutical action seem to have been made. *James K. Crook.*

MIGRAINE. See *Headache.*

MIGRAININE is a proprietary remedy stated by Overlach to contain nine parts of antipyrin and one of caffeine, and found by Hoffmann to yield 89.4 per cent. antipyrin, 8.2 per cent. caffeine, and 0.56 per cent. citric acid. Another analysis gives antipyrin 85 per cent., caffeine 9 per cent., and citric acid 6 per cent. (Coblentz). The dose is given as 1.1 gm. (gr. xvij.). *W. A. Bastedo.*

MILIARIA.—(M. alba; M. rubra; M. vesiculosa; Lichen tropicus, Prickly heat.) This is an acute inflammatory affection of the skin located about the sweat glands and their orifices, characterized by the formation of papules or of vesicles, or of both lesions together, ranging in size from a pinpoint to a millet or mustard seed, the color varying with the stage of the eruption, thus giving rise to the several names which have been given it, as M. alba, M. rubra, etc. It was called M. papulosa or vesiculosa according to the feature that was predominant in that particular instance.

The disease is more prevalent in the summer, and it attacks both sexes and all ages; we nevertheless see frequent cases during the winter months, especially in children who usually wear an excessive amount of woollen clothing. In the tropics the disease occurs during the whole year with equal frequency, and in all classes of people, independently of the clothing they wear. In such cases it would seem that heat alone is not the only cause which gives rise to the disease, but that some other factor is also involved, as, for example, the ingestion of highly seasoned or spicy food, or the use of alcoholics.

Crocker states that the disease may sometimes be unilateral in infants, and he attributes this to the fact that children are habitually held in the same position by the mother or nurse, as in nursing. This also explains why the disease is more often seen on the backs of infants, as they usually lie on their backs.

The onset of the disease is generally without premonitory symptoms; in adults we often have a history of profuse sweating with more or less itching or burning; in infants and children, for obvious reasons, we seldom get the same history of sweating, either because on the one hand they are not able to tell us or else because the mother or nurse is not sufficiently observant to notice the fact of its occurrence. The disease does not seem to have a predilection for any particular part of the body, save in the instances above mentioned, but it may attack any portion of it, as the back, chest, abdomen, face, etc. Frequently it is observed for the first time at an examination for a totally different ailment, and it is so well known that sometimes the patients come to us with the diagnosis of prickly heat, ready made, either by themselves or, in the case of children, by their immediate relatives.

Following the profuse sweat or concurrently with it, a papular or vesicular eruption appears in the vicinity of the sweat glands; the papules or vesicles are discrete, more or less numerous; in size they may be from that of a pinpoint to that of a millet or a mustard seed; in character they are acuminate; the color varies with the prevalence of the type: if papular it is bright red, if the vesicles predominate the red color will be more or less mitigated by the color of the fluid within the vesicles;

this alkaline fluid is at first perfectly clear, but later on it assumes a milky color, hence the name M. alba. When the predominant lesion is papular, as in the typical type of the disease, it has often been called lichen tropicus. This variety in the terms used has been the cause of great confusion.

The vesicles always remain discrete, having no tendency to rupture; sometimes the burning and itching are so intense that the sufferers scratch and tear their skins in the vain effort to obtain relief; these self-inflicted lesions at times become infected by the dirty nails of the patients, and when the sufferers come under observation the accidental features are apt to make the diagnosis difficult. If properly treated or if not unduly irritated, the disease ought to be of short duration, but sometimes it is lengthened by the successive appearance of several new crops of the lesions.

The pathology of the disease has been disputed: it consists of hyperæmia of the vessels of the sweat glands and a leucocytic infiltration about the sweat glands and their ducts; the latter are dilated and filled with a clear or an opaque fluid rich in cellular elements. Unna suggests the possibility of a micro-organism as a factor in this disease, but it has not been demonstrated.

Diagnosis.—Outside of those cases in which traumatism due to scratching or other irritation and subsequent infection has occurred, or when it appears in connection with some other disease, the diagnosis of this trouble ought to offer no difficulties. The one disease most liable to be confounded with it is eczema; the differential points are as follows: In miliaria the vesicles and papules are discrete, the vesicles are smaller, there is no tendency to rupture, they do not weep, no crust forms over them, the inflammation is not so deep-seated nor is it so intense, and it is more sudden in its appearance; if to the above we add the previous sweating, a history of exposure to heat, natural or artificial, and the amount and kind of clothing worn, the diagnosis ought to be made without trouble. It should, however, always be borne in mind that eczema of a secondary nature may supervene in this condition, as a result of scratching or other irritation; furthermore, eczema may also follow this disease independently of mechanical injury—for example, in the very stout, wherever two surfaces are in apposition, as between the buttocks, in the axillæ, etc.

The Prognosis is always good; the disease lasts between eight and ten days, or less, when properly treated; relapses are common, unless the original cause of the disease be removed.

Treatment.—First, if possible, endeavor to remove the original cause. Cold or cool water baths are useful. The bowels should be kept open by the use of saline laxatives, or mild diuretics, like the citrate, acetate, or nitrate of potassium. Locally, any one of the innumerable dusting powders on the market is useful; lotions are also very useful, viz., those containing alcohol, vinegar, lead water, carbolic acid, menthol, or sulphate of copper, any one of which will help toward the cure of the disease.

N. J. Ponce de Léon.

MILIARIA RUBRA. See *Lichen.*

MILITARY HYGIENE.—This paper is confined to the application of hygiene to the troops of the United States. It is necessarily limited to a dogmatic expression of the practical essentials with little discussion of the principles involved, and it treats only of those matters which affect the soldier as such. Until recently the United States army has consisted of a small body, about twenty-five thousand, of well-selected and well-instructed men distributed among somewhat crowded garrisons throughout the country. The organization has been such that the enlisted force may be more than doubled for active operations, without increase in the number of officers. The peace minimum has been much enlarged by the legislation of 1901, but the principle by which the rank and file may be increased remains the same. In time of war there is added a new army of volunteers, whose men are often accepted without proper scrutiny. The preservation of these men from disease is the chief concern of the medical officer, miscalled the surgeon. The medical officer's first duty is rigorously to examine his command, if it has been newly raised, and inexorably to eliminate all men unfit for full military duty. Upon the medical officer who examines recruits for enlistment lies a heavy responsibility, for it practically rests with him to determine the physical efficiency of the command. Unfortunately in time of war, when the necessity for effective men is the greatest, this selection is apt to be devolved upon untrained civilians who have neither the special knowledge that fits them as judges nor the position that enables them in doubtful cases to withstand the constant importunities of still less informed recruiting officers. The careful examination of recruits is not practical hygiene, but the successful application of hygiene requires carefully selected men to secure the best results. (See *Recruiting Service, Army.*) When a command has once been mustered in, the discharge of men not unequivocally disqualified is difficult; nevertheless every newly raised regiment or detachment should be held in a detention camp for careful weeding out of the imperfect. The effectiveness of a force depends upon its vigor rather than its size. The presence of the sick and the feeble is depressing and embarrassing. Only robust men should be allowed to bear arms, and discharges for pre-existing disabilities should clearly set forth their civil origin, to protect the state from fraudulent pension claims. Such pruning is important because some apparently slight blemishes develop under exposure, and all defects afford occasion to claim exemption from unpleasant duty. The temporarily weak and invalid should also be excluded by examination from any serious march or expedition, due allowance being made for malingering. Abundant work can always be found at the base for those incidentally unfit for vigorous marching, whose presence with it would only impede a column. Experience invariably confirms the importance of such selection, and that it is better to maintain a small sound command than a large one of doubtful vigor.

The enlisted men are provided with clothing, food, shelter, and occupation; and their whole duty is discharged by prompt obedience to their military superiors, upon whom rests the serious responsibility of their care. This care is practical hygiene and in every respect, excepting that which involves the direct shock of arms, the medical and line officers share it. The one should instruct, the other enforce the instructions. In the nature of military administration there can be but one commanding officer at a time, but all commanders are morally bound to follow the advice of an intelligent staff as to the health of the troops, where military considerations do not compel the temporary subordination of sanitation to active operations.

In treating of the soldier, infantry is taken as the type, the special conditions of cavalry and artillery not affecting the general conclusions.

Clothing.—The primary object of all clothing is to secure the comfort of the wearer by protecting him against wet, by conserving the heat of the body when the external temperature is low, by shielding against solar heat, and by preventing suffering from heat generated by exercise. Its secondary object, in a military point of view, is to increase the soldier's legitimate pride in his calling and to recognize him easily, but to keep him inconspicuous to the enemy.

General Character.—Soldiers should be dressed as nearly alike as possible, and attractive dress adds to self-respect; but a soldier's business is war and his working clothes should be adapted to it. For convenience of administration the clothing should be uniform by arm and the field dress of State troops, who at any time may be called into active service, should be identical with that of the Federal troops so that it may readily be supplied from the common store. The men are liable to suffer when damaged clothing cannot easily be replaced, which is apt to be the case when it is of special cut or has other

peculiarities. For parade and the purposes of display the ornateness of a uniform need only be limited by taste and expense, and its snugness of fit by the duty required.

Color.—The color of the outer garments should be neutral. For sentimental reasons blue, which is not a desirable military color, has long characterized the United States uniform, and it is only now (July, 1902), that olive-drab is about to be substituted in the field. Cadet-gray, dust-brown, and the so-called butternut dye used by the Confederates in the Civil War, are much more serviceable than blue, and gray was advocated for the United States troops as long ago as 1868. Upon the neutral tints any distinguishing facings are adaptable for ornament. In action colors draw fire in proportion as they are conspicuous, red being the most deadly and white the next; the scale continuing black, dark blue, light blue, butternut, dust-gray. As exposed to long range guns, there should be nothing to break the uniformity of color. The khaki (dusty) uniform in vogue is admirable, especially for arid countries. Color out of the sun's rays is not a factor of heat, but under direct exposure to the sun black absorbs most and is the warmest, blue is the next, and so down the scheme to white, which is the coolest. The absorption of odors depends partly upon the color, where black takes up the most, blue next, and white the least, and partly upon the hygroscopic character of the material.

Material.—The ordinary and most serviceable material for use in all but tropical and sub-tropical climates is woollen cloth. In very hot regions it should be cotton duck; the finer textures of cotton, as sheeting, which are suitable for civil life, are too light for military use. It must always be remembered that clothing does not create warmth except as it absorbs solar heat from the direct rays, which is a matter of color and not of texture, and that it is regarded as hot or cool in proportion as it retains bodily heat or permits its escape. Woollen cloth is durable, hygroscopic, and an excellent non-conductor of heat. It absorbs water within its fibres (hygroscopically), and between them (by interposition), and the hygroscopic absorption by wool in relation to cotton or linen is double in proportion to weight and quadruple as to surface. The sensation of warmth that follows putting on dry woollen clothing when the body is rapidly cooling by evaporation from the surface after excessive exercise, depends upon the condensation of the vapor and the consequent evolution of heat, which had become latent when the water of the body passed off as insensible perspiration. Woollen clothing rarely becomes saturated with perspiration, and when it does much of the water may be wrung out and condensation and absorption will continue. The non-conductivity of dry wool and its comparative impenetrability by wind make it acceptable in cold and oppressive in warm climates. Closely woven cloth is preferable to that of loose texture as more easily parting with dust, but where the temperature is moderate, serge, which admits the passage of air more freely than heavier cloth, has the advantage of lightness as well as the good qualities of the lesser woollens. Shoddy, which is old, worked-over wool and cloth sometimes mixed with fresh wool, is an adulteration most easily detected by the ease with which it is torn. From the qualities described wool, and especially dark wool, is unreasonable and hurtful as apparel in extreme southern stations where the air for long periods together is above the normal temperature of the body and slowly enervates the system. The constant disadvantage of wool is its hardening and shrinking when imperfectly washed, whereby it loses its faculty of absorbing perspiration and also becomes uncomfortable. This is best overcome by using a smoothly knitted merino, two-thirds wool and one-third cotton. Soiled woollens are best washed by soaking and stirring in hot soap-suds, transferring to cold water to remove the soap, and finally hanging to dry in their natural position without at any time wringing or hard rubbing. This is practically impossible in the field, and very difficult for a soldier anywhere. Excess of alkali in soap injures the wool by acting on the natural oil. A little kerosene assists to remove the dirt.

There is a widespread opinion that flannel next the skin renders the wearer less susceptible to the malarial poison. It probably does partly protect against the stings of possible disease-bearers, as compared with thinner and less perfect dress, and by conserving bodily heat renders the person more resistant to general disease.

For special purposes leather, canvas, oiled cloth, and india rubber are used. Properly tanned leather, with or without the hair or wool, is impervious to air and is very warm, but except in rainless climates it is fit only for boots or shoes. The special virtue of canvas is that it sheds water. It is heavy and is an excellent non-conductor of heat, and lined with wool is admirable against external cold. A light and loose canvas overdress, thoroughly washed and soaked with raw oil and slowly dried in the sun, known as a "slicker," sheds rain admirably and is especially useful for mounted men, but it has not yet been officially recognized. India rubber completely protects against rain, but its impermeability to air allows it to be used only occasionally. It becomes inelastic in cold climates and is too distensible and self-adherent in the tropics. It ultimately decays by the absorption of oxygen. Its greatest value is as an underlying sheet to protect against ground moisture, or when thrown over a shelter tent, or over the man himself on the march, to shield him from heavy rain.

A simple method of rendering clothing waterproof has been devised recently and independently by Capt. E. L. Munson, Medical Department, United States Army, and Dr. Pierre Kolb, of Lyons, France. It consists in immersing the fabric for about five minutes in a solution of 25 to 30 gm. of pure lanolin to 1,000 c.c. of benzin, when it becomes saturated. Any excess of solution is removed by wringing and the garment is then hung up smoothly or spread out flat in the open air and the sun, and the remaining fluid is allowed to evaporate, leaving the lanolin in the fibres of the fabric. Articles thus treated are not wetted through by exposure to heavy rain for at least three hours, although water may be forced through them mechanically by pressure exceeding one inch. As ventilation is not impaired, these fabrics may be worn without feeling the uncomfortable and depressing heat of wet clothes and without bearing the additional weight of absorbed water. The military advantages are the retention of their shape by hats and caps, general protection against wet, and the elimination of a rubber poncho or blanket as an additional article.

Animal materials are more satisfactorily treated in this way than vegetable fabrics, although the latter may be led to shed water. Boiling water or strongly alkaline soap destroys this quality of a garment, but it may be renewed by again immersing it in the water-proof bath.

Wool fat deprived of its potash salts and aromatic constituents is as efficacious as lanolin and is cheaper. The lanolin of commerce contains twenty-five per cent. by weight of water mechanically incorporated, which must be removed or the solution will be milky and the result unsatisfactory.

Grades.—For health and comfort clothing should vary in warmth and in material with the climate and with the service. Formerly a uniform fairly well adapted for the middle zone of the United States was the only one for all places and for every duty. By degrees this narrow uniformity has been modified, and the very severe weather of the more intolerably cold posts of the northwest and that of the tropics are being recognized. Varieties of clothing are relatively expensive to keep in stock and troublesome to issue, but the improved health and comfort of the wearers justify the effort. There should be different grades in both outer and under clothing, and when the climate requires it the materials themselves also should vary as has very recently been authorized.

Uniform.—The United States soldier is expected to wear a cap, a felt service hat, or a cork helmet, a coat and trousers of one of four patterns, or breeches, a shirt, an undershirt, drawers, stockings, shoes, and gloves,

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and to possess an overcoat and a blanket. He wears leggings with breeches, and canvas fatigue clothing under certain conditions, and when circumstances require he may obtain fur gauntlets and cap and mittens, and a rubber poncho. Besides his pay he is given a money allowance for the purchase of this clothing at cost price, and it is sufficiently liberal to permit a large proportion to be saved by a careful soldier, who receives the balance in cash on his discharge.

Head-covering.—The ideal military hat should protect against heat, cold, rain, and glaring sunlight. It should

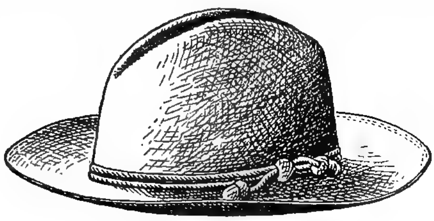

FIG. 3335.—Service Hat as Issued.

be attractive on parade, convenient under arms, and useful in bivouac, and it has yet to be devised.

A black felt helmet, that combined nearly all the possible hygienic objections to a military hat, has just been abandoned, and it is hoped that it may never be revived. For it has been substituted a dark-blue cloth cap, three and a half inches deep, with an average diameter of eight and three-quarter inches across the top, to be used on occasions of ceremony. For habitual wear in garrison, except at drills and target practice, a service cap of the same size and shape is to be worn, olive-drab in color, woollen or cotton to match the uniform. This seems well suited to its purpose and likely to be comfortable. Its appearance is a matter of taste. It does not protect below the line of contact with the head.

A white helmet may be worn, at the discretion of the commanding officer, in hot climates with white uniform when not under arms. A drab service helmet, of cork or like body, is authorized, apparently to be worn when under arms, although this is not specified. A cork helmet, white or drab, is an excellent guard against a fierce sun, and is comfortable, except in the field, where it can be taken care of only with great difficulty.

A service hat of drab felt is now issued for drills, marches, and field work, mounted or dismounted, the equivalent of the campaign hat heretofore used (Fig. 3335). It is tolerably high in the crown, whose centre is depressed in a longitudinal crease, and has a moderately broad brim. This is more serviceable than any hat for the field yet furnished to the army at large. Having found that the fold in the top diminishes the air space and retains rain-water, some commands have drawn the central point upward to form a pyramidal peak (see Fig. 3336). It

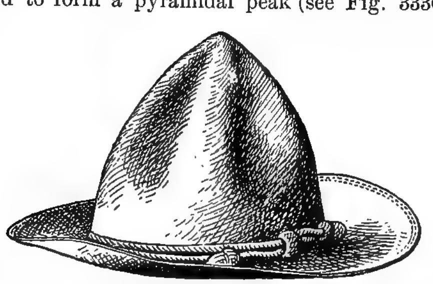

FIG. 3336.—Service Hat, as Forbidden to be Worn, but more Comfortable.

then sheds water, affords an air space, and is more comfortable. War Department orders forbid any alteration of the original shape, the advantage of the change apparently not being understood.

The soldier's head-covering should be light in weight, neutral in color, tasteful to the eye, not in the way of his own weapons, a shelter by day, and in the field a protection by night. It should not charm the spectator at the expense of the wearer, and in tropical regions it is very desirable that the occiput should be well protected by it. A soft canvas hat such as sportsmen often wear, which appears to have been evolved from their necessities so similar to those of soldiers, has stood the test of much rough usage and bears an excellent reputation for comfort and durability. It has a reasonably stiff but flexible brim with a peak before and behind, and could be transformed into a good military headdress for the field or for fatigue (Fig. 3337). In the tropics the crown should be high and be ventilated. A small piece of wet muslin in the crown of any hat assists in preventing insolation.

Coat.—Up to this time a tightly buttoned, closely fitting, cloth frock-coat has been required to be worn on parade. This was the remains of a dress that formerly distinguished all armies, and was a possible relic of the attempt to impose upon soldiers through clothing the artificial erectness and rigidity that armor compelled. No man can fight or do other work effectively in such a dress, whose compression interferes with muscular action and the expansion of the chest. For years it was never taken in the field, where the progress of military science has required constantly increasing mobility in the individual as well as in the organization. It had no virtue but warmth, and now it has been definitely abandoned, we may hope, like the heavy black helmet, never to be restored. It was an extension of the principle of the vicious leather stock, also no longer seen. A sack coat of dark-blue cloth, presumably not tightly fitting, has just been substituted for purposes of parade and ceremony only, and it is not supposed that even this will be required in the tropics.

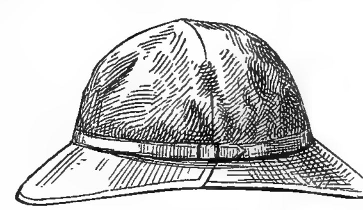

FIG. 3337.—Sportsman's Canvas Hat.

Tight collars, whether of coats or shirts, have the serious disadvantage of disturbing the cerebral circulation, thereby sometimes affecting the vision and sometimes causing graver trouble.

For some years the undress coat or blouse, the working dress of the army, has been gradually approaching the model of a hunting-shirt, which is the typical military dress, and to it in some form all woodsmen and frontier scouts ultimately come. Freedom of muscular action and particularly full expansion of the chest are necessary for vigorous exertion, and these require loose garments. The ideal military coat for the field should follow the figure with yokes and gores, but loosely; it should be large at the shoulder and in the arm, for the most unconstrained exercise of a muscular man, and small at the wrist; it should be full in the body, to permit the use of extra underclothing without interfering with exertion; it should have a belt between the body and the skirt, upon which the waist belt of the accoutrements may rest accurately; it should be secured at the waist by an inner belt; and it should contain stout pockets in the body and in the skirt. The skirts should just clear the ground on kneeling to fire. This might be embellished at pleasure with detachable ornaments for garrison use. For use in temperate climates the fabric should be closely milled, light woollen cloth, neutral in color, or a good grade of flannel; for tropical service it may be of cotton. The service coat of woollen or cotton now prescribed, which is required to be cut so as to be at least five inches in excess of the chest measurement, closely follows this pattern, except that there is no belt. It contains four outside pockets in front, two above and two below the waist belt, and is a very convenient garment.

The issue of a bleached cotton-duck sack coat and trousers is authorized as garrison uniform in extreme southern latitudes in summer, at the discretion of the

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commanding officer. The trousers alone may be worn under arms as a part of the "full dress" or "dress" uniform, for parades and ceremonies, by order of the commanding officer. The relief from the oppressive woollen that was formerly compulsory is a material physical advantage. White duck clothing is provided for all hospital corps soldiers, to be worn on ward duty.

Shirts.—Olive-drab flannel overshirts of light and heavy material, with rolling collar and pockets in the breast, are issued and may be worn without the coat on fatigue and under certain conditions in the field. Provision is made for the insignia of both officers and non-commissioned officers to be attached to the shirt when the coat is allowed to be laid aside, and it thus closely approaches the hunting-shirt already commended. If these were made in many sizes with and without collars, men would be able to wear one over the other in cold weather. Undershirts are issued of cotton and of light and heavy knit wool. There is risk in the fabric being so coarse as to be unendurable by delicate skins, and being too short for complete protection. Whether the outer shirts may be worn in duplicate or not, the undershirts should be arranged for that purpose; for animal warmth is better conserved by the layers of contained air between several garments than by one shirt of the aggregate thickness. Lumbermen and ice-cutters, and others exposed to severe weather while working, use several shirts in preference to an overcoat. Undershirts should be light in color, to avoid undue absorption of animal odors. They should be long enough fairly to cover the abdomen after they are washed. A linen neck-band prevents undue shrinkage at the neck. An extra shirt should always be carried for wearing next the body in the field, that the two may be worn alternately. The underclothing that becomes saturated with perspiration and dust should be dried and stretched at the end of the day's march and be well beaten.

Trousers and Breeches.—Sky-blue kersey trousers are issued for dress occasions. Heretofore the cloth trousers have been made in two grades, neither of which was well suited to climatic conditions. Now that cloth is limited to occasions of ceremony, the relative thickness is less important; but it should be closely milled, one grade very light, and it would be better if a third grade especially thick should be provided for winter use on the northwestern frontier. Bleached cotton and brown cotton duck trousers to be worn exceptionally, as are the corresponding coats, are also supplied. Military trousers should be large over the pelvis to allow the evaporation of perspiration, but should fit snugly about the waist. A broad inner band might be arranged as a secondary support. A russet leather belt or a pair of suspenders is now issued to each man. Opinions differ as to the propriety of suspenders, but it is my own judgment that a man whose hip bones will not sustain his trousers without undue pressure upon the abdomen is not physically qualified for the military service. Trousers should have large pockets, and those for foot-troops should be sufficiently narrow at the bottom for their convenient stowage within gaiters. Full-bottomed trousers may look better on parade, and the constant tendency of the enlisted man is to alter the ordinary issue to "spring-bottoms" unless the company commander maintains a watchful and repressing eye. But the distressing condition in which troops reach camp after a muddy march appeals strenuously against leaving the bottoms of trousers large or flowing. During the Civil War and later, foot-soldiers would frequently draw the stocking legs over the folded ends of the trousers, and hold both in place by wrapping them with string. The saddle pieces in the reïnforced trousers for mounted troops should be turned in, to avoid the rapid fraying of the ragged edge. On the plains the infantry often face the lower six inches of the legs with buckskin or canvas to avoid cutting out by grass, which might well be done before issue with all designed for the field, did not the habitual use of leggings obviate the necessity.

These general remarks on military trousers have little immediate bearing upon the United States service, as so-called breeches are about to replace that garment excepting for dismounted dress occasions and strictly garrison duty, neither of which involves continuous exposure or strain. They are still applicable in practice to the State troops, and belong to a general discussion of the subject. The service lower garment, as now prescribed for both mounted and dismounted regular troops for all duty out of garrison, is breeches to match the service coat in color and material. These are loose about the knee, fitting the leg closely and extending to the top of the shoes, where they are fastened with tapes or laces. Breeches proper, as the name implies, extend from the waist to mid-thigh or to the knees. These would better be called ankle breeches. Service trousers, of the same material and color as the service coat, are for habitual wear with or without arms in garrison. White trousers may be allowed, not under arms, in hot garrisons.

Drawers are primarily for cleanliness and secondarily for warmth. Several grades are now prepared, and care should be taken that the proper one is actually issued. The man is sometimes tempted to discard drawers, to the ultimate decrease of his comfort and at occasional risk to his health. The dusty trousers saturated with perspiration quickly become filthy, and the heat and coarseness irritate and excoriate the legs. With cotton clothing drawers are necessary to provide against a lower temperature at night, as well as for cleanliness. A very thick knitted woollen might be made for arctic and sub-arctic posts. Drawers should be of the same cut as suggested for infantry trousers with plenty of room in the seat, where they frequently are deficient, and when not of elastic material they should be fastened with tapes instead of buttons. The wearing of drawers should be enforced through inspection by company officers; but that drawers may be worn, the grade should correspond with the climate.

Stockings are issued in woollen and cotton. Woollen stockings frequently lead to the feet being chilled in the winter by excessive moisture from the retained perspiration, so that men who have a tendency to excessive perspiration should use cotton regardless of the season. The men should always be cautioned against folds or creases in the stockings as leading to sore feet; and in hot and wet regions soldiers may sometimes be authorized to discard stockings, so as to avoid the chafing caused by mud entangled in them within the shoe. In some armies the stocking is replaced by pieces of muslin wrapped smoothly about the feet. These are more easily kept clean than the ordinary stocking, and when skilfully applied do not irritate the skin.

Boots and Shoes.—Campaigns are won by marching, and soldiers cannot march with crippled feet. It is as necessary for the infantry that is not accustomed to going barefoot to be well shod, as it is for the cavalry horses to have their feet well protected. Officers sometimes under-estimate the importance of foot-gear, and even General Sherman went so far as to announce officially that it was a matter of indifference what shoes were worn. But serviceable feet are indispensable and if shoes are worn at all they must fit well, which means anatomically and without pressure, and they should be durable. A good shoe should have a thick wide sole, a low broad heel, it should neither be tight over the instep nor large enough to chafe, it should have no seams to press upon the skin, and

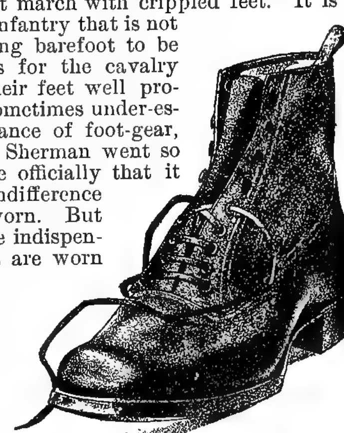

FIG. 3338.—An Army Shoe.

it should allow one-tenth of the foot in length and one-eighth or one-ninth in breadth for its expansion under exercise (Fig. 3338). The best heel has a narrow iron rim at the rear. Shoes frequently have too much leather in front of, and not enough over, the instep. Good shoes will last about two months in constant marching over reasonably rough roads. Under more favorable circumstances their life is much longer; but with the sand and gravel of regions like Arizona they will cut through much more quickly, unless protected by the hob-nails which experienced men always introduce. A poorly made shoe will sometimes almost fall apart when a single stitch is cut by grass or gravel, or when under extreme heat and dryness a few pegs or screws loosen. To carry extra shoes upon the person is a considerable tax upon the soldier's strength, and sub-depots for such supplies should be easily accessible. As so much of a soldier's comfort and efficiency depends upon his having a proper shoe, it becomes the medical officers of National Guard regiments liable for active duty either in the State or Federal service, and especially those of newly raised volunteer regiments, to impress upon all concerned the supreme importance of substantial, well-fitting, and comfortable shoes. In the field all shoes should be occasionally greased to render them more flexible and to repel water, and they should be occasionally water-proofed. For garrison use there is supplied a light brown canvas shoe that may be worn in barracks. White canvas shoes may be worn with the white uniform, but not on duty. The English issue a stout water-proof slipper for use in camp after a day's march, but with our lighter shoe it is not worth while for the man to carry this additional weight.

Boots, hitherto the mark of the mounted soldier, which are very ill-suited for dismounted duty, are no longer to be worn by any enlisted men. Both black and russet leather shoes are official, but at this time no particular pattern is obligatory. The black shoe must be worn on dismounted "full-dress" and "dress" occasions. On all other duty the russet shoe, which better retains its appearance in the field, is required. It seems unfortunate that a standard shoe in numerous sizes is not adopted. A good shoe is so important for the welfare of troops, and so few soldiers, particularly recruits, are competent to judge of more than its appearance without regard to its utility, that without unceasing and intelligent vigilance by company officers, great risk will be run of permanent damage to the feet.

Parkes ("Practical Hygiene," 7th ed., p. 531) says: "The sandal in all hot countries is much better than the shoe, and there is no reason why it should not be used in India for the English soldier as it is by the native; the foot is cooler and will be more frequently washed." In the tropics a light sandal may well be supplied for camps and for active service at discretion. Where the march is not through thorny ways a durable sole is sufficient, and an otherwise bare foot is more comfortable. Some of the Spanish troops in the Philippines wore a shoe of this description that seemed serviceable.

Leggings of cotton duck or canvas, of the color of the service uniform, are now required for troops of all arms on any other than ordinary garrison duty or occasions of ceremony. The exact specifications are not accessible at this writing, but those heretofore used were of brown cotton canvas in various sizes. They were laced at the side and held under the foot by a strap and buckle. Light canvas is apt to wrinkle, and light leather to become harsh under wetting; and, as heretofore made, the strap under the sole easily tears and wears out. They should always reach nearly to the knee, and would be better if well-fitted and clasped with a spring. When properly adjusted they afford a grateful sense of support, and they preserve the leg and ankle from sand and dust and mud. When tight enough to remain accurately in place, they are liable to be too tight and to lead to swelling of the feet and ankles. That is a possible objection also to fastening the breeches with tapes.

The British troops in Asia use putties. These are long bandages extending from the ankle to above the calf, applied as the ordinary spiral roller. The men soon learn to adjust them neatly and securely, so that they do not require re-arrangement on the march, and they seem to serve their nominal purpose much better than the leggings, and as additional articles of uniform they are more portable and are more easily cleansed. The mounted troops use them equally with the infantry.

One of the chief factors of the efficiency of any command is its mobility, and this depends in large part upon the condition of the feet. Therefore an important part of a company officer's duty is careful and frequent inspection of the lower extremities and the supervision of their care. That includes seeing that the nails are properly trimmed directly across the toe, that corns and chafes are guarded against, and that cleanliness is practised. Corns and chafes depend upon ill-fitting shoes. Men unaccustomed to marching should soap or grease the feet before setting out; and when camp is reached should wipe them clean, for which but little water is required. Blisters are to be allowed to drain through a minute hole at the most dependent point. A powder first used by the Germans consisting of salicylic acid 3, starch 10, and powdered soapstone 87 parts by weight, when sifted into the stockings keeps the feet dry, obviates chafing, and facilitates healing. This is more economically used in the form of ointment. Of course it does not neutralize the bad effects of improperly made shoes. When in spite of care raw troops break down from foot-soreness, it is necessary to carry them in wagons. Such transportation should not be long deferred, neither should men be carried on account of moderate discomfort from their own neglect. Soldiers disqualified by their own neglect should be punished.

Overcoat.—The soldiers' overcoat is to be of olive-drab woollen material, in general design like the officers' overcoat. This is doubtless wisely to make the officers less conspicuous than they heretofore have been under fire. The officers' coat upon which this is patterned is a double-breasted ulster extending eight or ten inches below the knees, with a detachable hood large enough to cover the head when worn at night or in inclement weather. The front corners of the skirt may be turned back for convenience in marching. This coat has no cape. Waterproof overcoats or capes as near as may be the color of the service uniform are permitted to be worn on duty when exposed to rainy or other inclement weather.

Blankets.—Every man is required to have at least one woollen blanket of the regulation issue, five and a half by seven feet in size and weighing five pounds.

Poncho.—The poncho, a rubber sheet with a central slit so that it may be worn over the shoulders on the march in the rain, or be laid under the soldier in camp, has been removed from the class of "equipage" into that of "clothing." It is not a part of the regular allowance but is supplied at cost and is very useful in damp climates.

Gloves of drab-colored leather are to be worn with the service uniform, and white Berlin or wool at dismounted ceremonies. Gauntlets are abandoned.

Fatigue Suits of brown cotton duck are allowed in garrison for men on stable or fatigue duty, or with fixed guns and emplacements. These may be worn alone or over the uniform.

Abdominal Bandage.—A woollen bandage is issued in hot climates for the protection of the abdomen. This encircles the loins and is supposed to protect the kidneys as well as the intestines. The official pattern, which does not appear to have been evolved from experience but from theory, is neither comfortable nor very effective, and is liable to roll up into a comparatively narrow band. A much better form is that of a small flannel apron of one or two thicknesses, from fourteen to eighteen inches wide and from six to eight deep, tied by a tape around the waist and worn next to the skin. This abdominal protector will materially lessen the chance of those intestinal affections that depend upon abrupt changes of tem-

perature and make serious inroads upon the health of the command.

Special Articles, as hoods, gloves, overshoes, and overcoats of extra warmth are now issued at very cold posts for protection against the severe weather. This is eminently proper, inasmuch as formerly fifteen per cent. of such garrisons were off duty from frost-bite for several weeks every winter, besides the absolute inability of unprotected troops to take the field under extreme cold.

Woollen Comforters, such as some men will wear about the neck in cold weather if permitted, are usually harmful. They keep the throat bathed in perspiration and render it unduly sensitive. Speaking generally, a soldier should not wear any article of clothing not supplied from the public stores.

Because a soldier is completely deprived of a civilian's opportunities for personal provision, it is very necessary that the clothing he is compelled to wear should be perfectly suited to his arduous work. War inevitably tears away the non-essentials of dress, but unfortunately does not supply the deficiencies it develops. Therefore their wants should be carefully anticipated and provided for by the officers who are responsible for the comfort and efficiency of their men. Furthermore, war is apt to be accompanied by lower commercial standards, and deterioration under the pressure of great demands will always lead troops to suffer unless rigorous inspection and inexorable rejection intercept unsound and defective supplies.

Weights to be Carried.—The soldier in the field carries upon his person all that is necessary for his complete independence in the presence of the enemy. Formerly his extra clothing and small articles, and in emergencies part of his ammunition, were carried in a knapsack. This was slung between the shoulders supported by straps that crossed the chest and also passed under the armpits. The pressure over the heart and lungs and the constriction of the axillary vessels and nerves by these straps, with the discomfort from its presence on the back and its great weight, always made the knapsack peculiarly obnoxious in both our own and foreign armies. It is probable that no other condition of the service has been responsible for such physical discomfort and for so much ineffectiveness, not to say disability; and constant effort has been made to lighten both the amount and the severity of the soldier's burden. In the effort for relief the blanket bag was substituted in 1882. It is practically a knapsack, although it leaves the chest freer (Fig. 3339). This also, which was never satisfactory, is now (1902) after trial for twenty years to be abandoned. Its object was to keep the enclosed blanket dry and clean, and to carry a few small necessaries in its pocket, with the rolled overcoat resting on the top. In practice the spare shoes and the other clothing were put in the bag and the blanket was rolled under the overcoat. It was made of duck and had a total capacity of 990 cubic inches. Its weight with the straps was a little more than two and a half pounds. The remainder of the equipment consists of a haversack to hold three days' rations, with three small bags for coffee, sugar, and salt, and a canteen of three pints' capacity, with their straps; a tin cup, a meat-can divisible into two independent dishes, and a knife, fork, and spoon. These weigh nearly four pounds six ounces. The accoutrements are a cartridge belt and plate, gun-sling, and bayonet scabbard, which weigh about two pounds. Thus the carrying apparatus weighs about six and a half pounds. To this must be added a rifle and bayonet weighing ten and one-quarter pounds and one hundred rounds of cartridges weighing nearly six and one-third pounds. Hence, without reckoning food or clothing, the soldier in line of battle carries about his person twenty-three pounds' weight of appliances. To this must be added three pounds of water in his canteen and five pounds of bread and meat, as three days' rations, in his haversack. The contents of the blanket bag were ordinarily one blanket, a towel, comb, brush, soap, socks, and overshirt, an undershirt, and a pair of drawers, the contents weighing in all nine pounds. The old-pattern overcoat weighed six pounds ten ounces; and for the shelter tent two pounds must be added. The weight of the new coat must be approximately the same as that of the old. The weight of the clothing and kindred articles besides what he is wearing, and exclusive of an extra pair of shoes upon which some authorities insist, is seventeen and one-half pounds. The ordinary clothing actually on the person weighs about ten and one-half pounds. Consolidating all the burdens, we find that the American soldier in heavy marching order, and carrying, as the regulations presume, three days' rations, bears nearly sixty pounds. The weights borne by the British and the Austrian soldier are also about sixty pounds, the French and the German carry about sixty-seven, and the Russian and Italian about seventy-five pounds. These are approximate figures which vary according to the conditions, and all are probably reduced in the field. In fact the United States soldier often places extra underclothing and a few light articles within the blanket which he rolls into a long cylinder and, with its ends tied together, carries it *en écharpe.* This is popularly known as the blanket roll, which has long received semi-official recognition and now is formally recognized. It is safe to say that in the immediate presence of the enemy the blanket bag has always been replaced by the blanket roll. The shelter tent has lately been equipped with straps expressly to retain the blanket and contents in a roll, and the same order that discards the blanket bag accepts and authorizes the blanket roll "until some more satisfactory method of carrying the pack has been devised." Occasionally the overcoat and shelter tent half are also rolled and carried on the other shoulder, crossing the chest in the opposite direction. Although strong men carry these rolls more readily than they do similar weights in the knapsack or blanket bag, and they may also be discarded very easily in action, nevertheless even this reduced pressure across the chest is oppressive and, at least in some cases, interferes with the action of the heart. As noted by a military board in 1889 "such use [during the civil war] did not imply an approval of the roll, so much as a condemnation of the knapsack then provided for the troops." The double roll is more than doubly objectionable. Dr. W. T. Parker, formerly an acting assistant surgeon, has devised a clothing case of light water-proof material so arranged with interior pockets as to hold underclothing and small articles, which are necessarily dispersed when the ordinary blanket roll is opened. It is intended to be carried either within the blanket roll or independently over the shoulder. For the purpose this is an admirable contrivance, although it has never been introduced in the army (Figs. 3340 and 3341). The late Captain Dodge proposed a flexible wooden strip or yoke to which the roll would be lashed which would also take up the weight of the haversack and the canteen. It passes over the shoulder and rests, as the blanket roll would, against the opposite side. Where it crosses the collar bone there is an elastic leather strap, like a crutch-head, to take off the rigid bearing. The presumed advantage of this support is to relieve by its curve all pressure from the chest and back. If that can be successfully done and the weight prove not too great

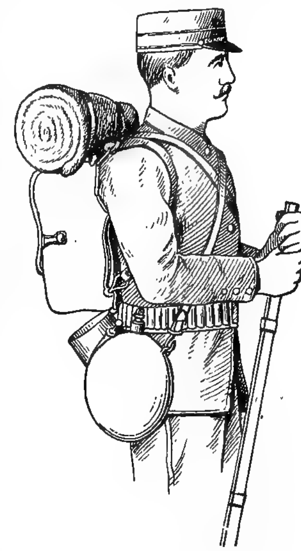

FIG. 3339.—The Blanket Bag.

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for the narrow line of the clavicle, the relief from pressure against the chest should make this a very useful appliance. It has not, however, received an extended practical trial. After all, it is the way in which it is carried

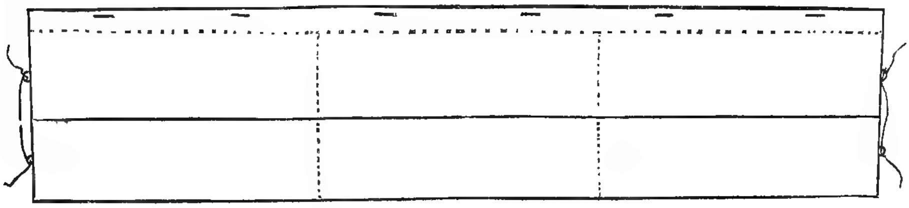

FIG. 3340.—Clothing Case, Open.

FIG. 3341.—Clothing Case, Packed and Folded.

rather than the actual weight of a soldier's necessary equipment that is trying the man. His respiration should not be impeded, the axillary vessels and nerves should be free from pressure, and the back should be exposed to the air as much as possible to facilitate evaporation. The nearer the load lies to the centre of gravity, the more easily it is managed. These various requirements have been most nearly attained by an equipment devised some years ago by Brigadier General Merriam, which in brief may be described thus:

The pack consists of two compartments and is designed for necessary underclothing, rations, and extra ammunition within, and for a blanket, a shelter-tent half, and, on occasion, an overcoat on the outside. It is carried in part by straps passing over the shoulders and hooking into the waist belt, but chiefly by two wooden supports that slip into sockets on a lower half-belt and rest against the hip

FIG. 3342.—Merriam Pack, showing Particulars.

bones. The supports by their inclination keep the burden away from the back, so that ventilation is maintained. To insure this the contents of the pack must be arranged so as not to bulge and press against the body. The waist belt does not require to be tight, but, if desired, may be left unbuckled while marching. The weight is supported by the hips with some assistance from the collar bones, and there is practically no pressure upon the back and absolutely none upon the breast. This avoids all constriction of the chest and of the armpits, which is the great evil in the ordinary methods of carriage. The supports are interchangeable and when joined form a shelter-tent pole. It is intended to carry a shelter-tent half and a blanket rolled over the top and sides of the pack, the underclothing, toilet articles, and, extra cartridges in the upper compartment, and the rations and mess kit in the lower. The canteen rests against the lower back of the pack. An overcoat may be carried under the pack. It is, however, less important to define exactly what articles should be carried than to determine and comply with the principles by which the necessary burden should be borne. In this respect numerous actual trials in the field have demonstrated the efficiency of this method, and there can be no question as to the practical value of this device and its great superiority over the lately official blanket bag in poise and freedom from oppression. If it should be desired to carry an excess of rations and ammunition, as in the active operations incident to battle, the underclothing and similar articles may be removed for the time and the pack become in effect merely a haversack and an ammunition pouch. On the other hand a prolonged expedition can be conducted n heavy marching order with the minimum of discomfort. In the Cuban campaign it was carried to the firing line, and no system known to the writer equals it for armies in the field. For the necessities of the National Guard, the Merriam pack, already adopted by some States, is unsurpassed.

FIG. 3343.—Merriam Pack, with Blanket.

FOOD is necessary to replace waste, to produce energy and animal heat, and to supply additional tissue for those who are growing. In general terms nitrogen and carbon represent the materials needed, and man requires fifteen times as much of the latter as of the former. Each of these must be arranged in particular form in order to be digested and assimilated, and the problem of all diets is to secure such food at a practicable cost. That is to say, a man must regulate the kinds of food according to his needs. Thus, if he were confined to a meat diet he would have to take up about four times as much nitrogen as is necessary in order to obtain sufficient carbon;

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or a bread diet would overload him with carbon before he received sufficient nitrogen. For while foods are classed in a general way as the albuminates or nitrogenous, and the starches and sugars or carbohydrates, and the fats, or hydrocarbons, these merely indicate their preponderating chemical qualities, and both nitrogen and carbon are to be found in almost every article of diet. Nevertheless, to live upon bread alone would require daily four and one-half pounds; upon flesh alone, six and one-half pounds, or upon potatoes alone, fifteen pounds, and only at the risk of ultimate disease from the excess of unnecessary elements, even supposing the whole to be assimilated. Albumen, therefore, must be supplemented by fats, starches, sugars, organic acids and salts, and bread requires flesh, fats, etc. It is not the quantity ingested but the amount assimilated that measures the value to the individual of the food taken. And as the assimilative powers of individuals vary as to each other, and among themselves upon occasion, the food for a number of men should cover the average requirement. Neither, even were it possible, should the food be of purely nutritive qualities, for the presence of a certain amount of waste seems necessary for the complete digestive health of man.

A ration is the allowance for the subsistence of one person for one day, and is not, as civilians occasionally suppose, that for one meal. Besides meat, bread, vegetables, fruit, coffee, sugar, and seasoning, it includes a proportion of soap and candles. It varies in its composition with the station of the troops or the duty they perform, and is therefore known as the garrison, the field, the travel, or the emergency ration, according to these conditions.

The garrison ration, issued to troops in garrison or in permanent camps, is as follows:

Meat Components: Fresh beef, 20 ounces, or fresh mutton (at no greater cost) 20 ounces, or bacon 12 ounces, or canned meat (when fresh meat cannot be supplied) 16 ounces, or dried fish 14 ounces, or pickled fish 18 ounces, or canned fish 16 ounces. In Alaska the allowance of bacon is 16 ounces, or (when desired) salt pork 16 ounces, or salt beef 22 ounces may be substituted.

Bread Components: Flour 18 ounces, or soft bread 18 ounces, or (only when flour or soft bread cannot be used) hard bread 16 ounces, or cornmeal 20 ounces.

Vegetable Components: Beans $2\frac{2}{5}$ ounces, or peas $2\frac{2}{5}$ ounces, or rice $1\frac{3}{5}$ ounces, or hominy $1\frac{3}{5}$ ounces, and potatoes 16 ounces, or potatoes $12\frac{4}{5}$ ounces and onions $3\frac{1}{5}$ ounces, or potatoes $12\frac{4}{5}$ ounces and canned tomatoes $3\frac{1}{5}$ ounces, or potatoes $11\frac{1}{5}$ ounces and other fresh (not canned) vegetables when obtained near by or transported in a wholesome condition from a distance, $4\frac{4}{5}$ ounces, or desiccated vegetables (when fresh vegetables cannot be furnished) $2\frac{2}{5}$ ounces. In other words, the daily vegetable ration consists of a reasonable allowance of dried vegetable food and also one pound of fresh vegetables or its equivalent. In Alaska the allowance of fresh vegetables is 24 instead of 16 ounces, and that of desiccated vegetables is $3\frac{3}{5}$ instead of $2\frac{2}{5}$ ounces.

Fruit Components: Dried or evaporated prunes, apples, or peaches $1\frac{3}{5}$ ounces (when practicable, 30 per cent. of the issue to be prunes).

Coffee and Sugar Components: Coffee (green) $1\frac{3}{5}$, or roasted and ground $1\frac{7}{25}$ ounces, or tea (black or green) $\frac{8}{25}$ ounce, and sugar $3\frac{1}{5}$ ounces.

Seasoning Components: Vinegar $\frac{8}{25}$ gill, or vinegar $\frac{4}{25}$ gill and cucumber pickles $\frac{4}{25}$ gill, and salt $\frac{16}{25}$ ounce, and pepper (black) $\frac{1}{25}$ ounce.

Soap and Candle Components: Soap $\frac{16}{25}$ ounce, candles (when necessary for illumination) $\frac{6}{25}$ ounce. In Alaska the allowance of candles is $\frac{8}{25}$ ounce.

The field ration, issued to troops in the field in active campaign, differs from the garrison ration chiefly in being less elastic. It is as follows:

Meat Components: Fresh beef or mutton (procured locally) 20 ounces, or canned meat (when fresh meat cannot be procured locally) 16 ounces, or bacon 12 ounces.

Bread Components: Flour 18 ounces, or soft bread 18 ounces, or hard bread 16 ounces, and baking powder (when ovens are not available) $\frac{16}{25}$ ounce, or (when ovens are available) hops $\frac{1}{50}$ ounce, or dried or compressed yeast $\frac{1}{25}$ ounce.

Vegetable Components: Beans $2\frac{2}{5}$ ounces, or rice $1\frac{3}{5}$ ounces, and potatoes (procurable locally) 16 ounces, or (procured locally) potatoes $12\frac{4}{5}$ ounces and onions $3\frac{1}{5}$ ounces, or desiccated potatoes $2\frac{2}{5}$ ounces, or desiccated potatoes $1\frac{23}{25}$ ounces and desiccated onions $\frac{12}{25}$ ounce, or desiccated potatoes $1\frac{28}{25}$ ounces and canned tomatoes $3\frac{1}{5}$ ounces.

Fruit Component: Jam (in cans) $1\frac{2}{5}$ ounces.

Coffee and Sugar Components: Coffee (roasted and ground) $1\frac{7}{25}$ ounces, or tea (black or green) $\frac{8}{25}$ ounce, and sugar $3\frac{1}{5}$ ounces.

Seasoning Components: Vinegar $\frac{8}{25}$ gill, or vinegar $\frac{4}{25}$ gill and cucumber pickles $\frac{4}{25}$ gill, and salt $\frac{16}{25}$ ounce and pepper (black) $\frac{1}{25}$ ounce.

Soap and Candle Components: Soap $\frac{16}{25}$ ounce, candles $\frac{6}{25}$ ounce.

These supplies are not issued in the small and fractional quantities here noted, which are set down to show the daily allowance assumed to be necessary to subsist each man, but are supplied in bulk, generally in quantities of one hundred rations or multiples thereof.

The travel ration is issued to troops travelling otherwise than by marching, or when they are separated for short periods from cooking facilities. It consists per hundred rations of:

Soft bread $112\frac{1}{2}$ pounds, or hard bread 100 pounds, and canned corned beef or corned beef hash 75 pounds, and baked beans 25 pounds, and canned tomatoes 50 pounds, and roasted and ground coffee 8 pounds, and sugar 15 pounds, or, in lieu of the coffee and sugar in kind, 21 cents per day per ration is allowed for the purchase of liquid coffee.

Troops on transports have their food prepared from the articles of the garrison ration, varied by the substitution of articles of equal money value from the extensive list of subsistence stores other than the ration kept for sale. Ordinarily, fresh meat is issued seven days in ten, and salt meat three days in ten, the issue of fish being a substitute for that of salt meat. Whenever the issue of both the fresh meat and the vegetable components is impracticable, there may be issued in lieu of them canned fresh-beef-and-vegetable stew, at the rate of $28\frac{1}{2}$ ounces to the ration.

The emergency ration, prepared under the direction of the War Department, is supplied troops in active campaign for use only when the regular ration cannot be obtained. Each complete ration is contained in a metallic case which may be opened only by an officer's order or in extremity.

It consists of a chocolate component and a bread and meat component. The first contains equal parts of pure chocolate and pure sugar combined, molded into a cake of one and a third ounces. The second contains meat-flour and parched ground wheat. The meat-flour is prepared by grinding fresh lean beef, free from visible fat and sinew, desiccating it by heat, without cooking it in the slightest, until the moisture does not exceed five per cent. and reducing it to a powder carefully sifted through a fine-meshed sieve. The wheat portion is prepared by parching cooked kiln-dried wheat with the outer bran removed, and grinding it to a coarse powder. The compound consists of 16 parts of the meat flour, 32 parts of the ground wheat, and 1 of common salt, each by weight, thoroughly mixed in sufficiently small quantities to be homogeneous. These are compressed into a cake weighing four ounces. Three cakes of the chocolate and three of the bread and meat component are put up in a can with three-fourths of an ounce of fine salt and one gram of black pepper, and are designed to subsist a man for one day. The meat and bread component may be eaten dry; or be stirred into cold water and eaten; or one cake may be dissolved in three pints of water, boiled five minutes or longer, and seasoned to taste; or one cake may be boiled in one pint of water five minutes to make

thick porridge, to be eaten hot or cold. When cold this may be sliced and fried with any available fat.

The Subsistence Department issues to the soldier, entirely at the public expense, all the parts of the particular ration required for him, whether in garrison or in the field. In most foreign services the enlisted man when not actually campaigning must buy a large part of his food, and his pay is arranged with a system of stoppages for that purpose. But in the United States army this is not required, nor would it be practicable for individual men or company organizations to make such purchases in a great part of the garrisoned or marched-over regions at home or abroad. The formal constitution of the ration, except as expressly noted, is uniform for the service required regardless of locality or climate. Manifestly it is exactly suitable only within very narrow conditions, if indeed to any. But the alternative and substitutive portions give it wide range, which is further increased by the exchange or sale of surplus parts and the purchase of other food with the accruing fund. Besides the money value of the unconsumed rations, the savings of the post bakery, as explained later, and a share of the profits of the post exchange go into the hands of the company commanders as a company fund. By the administration of the ration, and of this fund which in part represents it, the captain demonstrates much of his ability to take care of his men. The hospital fund, for the purchase of extra diet for the sick, is created in the same way. An alternative provision for the subsistence of the sick occurs through an allowance of forty cents per man per day. When circumstances permit, vegetable gardens are cultivated by their own labor for the benefit of the troops. Besides adding to the table, the profits of any sale or exchange of vegetables accrue to the company fund.

Speaking generally, the bread and meat components are the vital parts of the ration and those most likely to be issued even under adverse conditions. Bread is not a complete diet, in that it is deficient in fat and moderately in nitrogen, on which account some form of oily food is instinctively eaten with it. But it is the only part of the ration in which there is no necessary waste, and it is one of the very few foods that never pall upon the appetite. Bread is dough distended through its particles with carbon dioxide and cooked, and dough is flour mixed with salt and water. Flour is the crushed wheat kernel with the two outer husks or bran removed, and it contains from nine to fourteen parts of nitrogen and between sixty and seventy parts of carbonaceous matter in the hundred. The bran contains about fifteen per cent. of nitrogen, three and a half of fat, and five and seven-tenths of salts, but although theoretically nutritious is too irritating, and therefore indigestible, to be assimilated. On this account the use of whole flour is of doubtful wisdom. In the market "high patent" flour is graded the highest, but moderately dressed or "straight" flour, which is the whole product of the wheat except the refuse, with a small proportion of low grades, is the best for issue. Whatever the standard the flour should be uniform in color, for specks show imperfect milling or a very low grade; but the best flour is no longer, as formerly, necessarily an absolutely impalpable and white powder. The roller process yields a slightly rough flour, and the hard winter wheat may give it a yellowish tinge. Good flour is slightly acid to test paper but not to the taste, and an acidity that may be recognized by the senses means a change. Acid flour makes sour bread, and any disagreeable taste or odor indicates bad flour. When boiling water is poured on a little flour, there should arise no odor but that of freshly ground wheat. The relative strength and elasticity of the gluten, which are determined comparatively by manipulating a small quantity of flour intimately mixed with half its weight of water, make a standard for comparison. This is known as the dough test, and its failure shows weak flour, from poor wheat or imperfect milling and defective gluten.

The carbon dioxide is introduced within the dough, (1) by yeast or other ferment, (2) by a baking powder, or (3) by forcing the gas into the mass (aeration). The usual garrison method is to add eight to twelve pints of tepid water, four ounces of yeast, a little potato, and one or two ounces of salt to twenty pounds of flour, checking the fermentation at the proper point. When the dough is heated the albumen in the flour is coagulated, a part of the starch is transferred into dextrin and some sugar, and some additional carbon dioxide is formed. Yeast is the ordinary ferment, but a lump of leaven, which is common dough kept moderately warm for some time, may be thoroughly kneaded, while undergoing fermentation, into fresh flour and water. A good baking powder would be two ounces of tartaric acid and three ounces each of bicarbonate of soda and arrowroot—thoroughly mixed and kept perfectly dry (Yeo). Bread may be heavy when the yeast has fermented too rapidly or insufficiently, or when the heat has been too great or too little. Bitter yeast will make the bread bitter and excess of water may make it mouldy. If acid flour must be used, or if the flour has been grown on sandy soil where lime is deficient, it may rise well enough, but becomes heavy and sour upon cooling. In such a case mixing the flour with lime water made from quicklime will yield good bread. There are some soils the flour from which always requires strong lime-water. When the yeast is from stock that is too old, lime-water will sometimes act as a corrective. When bread is sour from an excess of acid it may be made edible by toasting it in thin slices, which volatilizes the acid. Stale loaves heated in an oven to 250°–300° F. after having been soaked in water are thus freshened; but they must be eaten within twenty-four hours. Thick slices of stale bread may be freshened by toasting.

At a permanent post the Subsistence Department establishes a bakery, and in that case it issues the flour in the form of soft bread only. As the gain in baking is about one-third, weight for weight, the bakery expenses are thus reimbursed; and should circumstances make it desirable the ration of bread, not of flour, may on account of such gain be increased up to twenty-two ounces, when ordered by the post commander on the recommendation of the council of administration. Bread loses weight after baking, and the weight of the bread ration is always taken cold. For large camps it is often practicable to establish great temporary bakeries, as was done successfully at Chickamauga, and perhaps elsewhere, in 1898. For marching columns bakery wagons and travelling ovens, such as were used with the Army of the Potomac, can accompany the troops wherever guns can pass. But in the field, where hard bread is not depended upon, baking for brigades or smaller commands will generally be done by the company cooks. Of the various methods of baking in the field, the simplest is to fill a small hole in the ground with a wood fire, and when this has thoroughly burned out to place in it on a stone a mixture of flour, salt, and water, covered with a tin plate and surrounded by hot ashes. The heat should be kept below 212° F., or the bread will be tough. Or two mess-pans may be taken and the rim of one be cut down an inch and a half leaving a rough border. Fill this pan two-thirds with dough and invert over it the perfect pan. Place both in a hole eighteen inches deep where a wood fire has burned several hours, and from which all the embers, except for two or three inches, have been removed. Cover the pans with hot ashes and earth and the bread will bake in five or six hours. The gases escape through the cut edges. A barrel oven is made by laying in a hollow a barrel with its head out, and covered throughout for six or eight inches with wet clay, and this for six inches with dry earth. At the top of the further end a three-inch opening is left for a flue. The staves are burned out, and after it has been heated for use the front and the flue are closed. The common Dutch oven is well adapted for baking for small messes in the field when fuel and transportation are abundant, and is a desirable part of company property. It is a heavy flat iron pot with short legs and a top which fits with a flange. It is heated by

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coals placed upon as well as beneath it, and several may be used together in a trench with economy. The Buzzacott field oven, now supplied by the Government, is well adapted for baking and general cooking. It has greater range and less weight and cost than the same capacity of Dutch ovens, and may be carried wherever there is moderate transportation. It requires more care to protect from injury than the heavy Dutch oven. Loaves of bread for transportation should be laid on their sides or ends, not on their bottoms. An army wagon with side-boards will carry 1,800, and without side-boards 1,400, 18-ounce loaves of bread.

Hard bread (military biscuit) is unfermented dough thoroughly baked. Bulk for bulk it is more nutritious than soft bread, on account of the water having been driven off; but men do not thrive on it as a constant diet. When issued in very small rectangular crackers put up in one-pound stiff cartons very little is wasted, as occurs by crumbling when large squares are served from the original packing-boxes.

Cornmeal may be substituted for flour at the rate of twenty ounces per ration. It contains quite as much nitrogen and four times as much fat and is highly nutritious. It does not keep well and cannot be abruptly substituted for flour with persons unaccustomed to it. Neither does fine wheat flour agree at first with those accustomed to meal. Both these rules were illustrated by military prisoners during the civil war; the Southern sickened on a wheat diet, as did the Northern men when fed on cornmeal. Oatmeal develops ounce for ounce 130 foot-tons of potential energy against 87.5 for bread; it keeps fairly well, it is easily cooked and, although from its lack of adhesiveness large loaves cannot be made, it may be used in small flat cakes. It is a good military food and as a hot or cold gruel is extensively and profitably used by hard-working laborers. This would be an admirable issue for men on guard at night or on heavy fatigue.

The bread is probably the most important part of the ration to the new soldier. Men recruited in peace have frequently been underfed before enlistment; while those of a higher social class who become soldiers under the stimulus of war often require an excess of bread to compensate for their non-assimilation in the beginning of their career of the coarser parts of the ration. In both cases bread is so acceptable a food that it is always eaten in excess. All the care that may be spent on its preparation is well bestowed.

Besides restoring waste and adding tissue to the immature, the province of food is to supply energy and animal heat. These are yielded by the contained nitrogen and carbon respectively. Almost any form of food contains both these elements, but speaking generally the energy-giving part of the ration is the flesh, whose most acceptable form is fresh beef or bacon. The ration of fresh beef is estimated on the basis of the raw issue. The carcass wastes five per cent. in cutting up; a fair proportion of bone is twenty per cent.; and in cooking meat shrinks twenty-five per cent. in weight. The issue is sufficient when the quality of the beef is good, but it is insufficient when taken from range cattle, or from carcasses kept long in cold storage. The loss in cooking frozen meat is believed to be ten per cent. more than with fresh meat, and there is further believed to be a deterioration in the nutritive value of refrigerated beef. This latter point has not yet been scientifically demonstrated, but it is probably the case. Salted meats lose some of their valuable constituents by osmosis into the brine, and their texture becomes hardened. In general terms, salt beef has two-thirds the food value of fresh beef. Issue steers should weigh about one thousand pounds and be about four years old and be well nourished. The average net weight is about sixty per cent. of the live weight, and when the use of scales is impracticable this may be determined by one or the other of these formulas:

$(C^2 \times .08) \times L \times 42 = W$ (net), where C is the girth behind the shoulder blades, L the length from the front of the shoulder blades to the tail, 42 pounds represent the weight of a cubic foot of flesh, and W is the net weight. In this case .08 is the equivalent of 0.7958, and the square of the circumference multiplied thereby yields the contents. Or $C^2 \times 5 L \div 1.5 = W$. Divide by 1.425 if fat, or by 1.575 if lean.

Beef should be killed twenty-four or thirty-six hours before issue in temperate and eight or ten hours in hot climates. The fat of good beef should be firm and sufficient and the flesh be firm and elastic, marbled from little veins running through it, and a little reddish fluid should exude. If the flesh is pale and moist it indicates that the animal was young, if dark that it was old. When the animal has not been properly bled the flesh is a deep purple in color. Blood should not be retained in the flesh, not because it is unwholesome but because it decomposes very rapidly. The interior should be no darker than the surface and there should be no softening of the tissues nor fluid within them. Commencing change is denoted by a disagreeable odor and by the color being paler at first and greenish later. Decomposing meat should not be eaten, although it may be tolerated by some digestive organs and be esteemed a delicacy by abnormal palates. Diseased animals ordinarily should be condemned as food, although such emergency issue may be made in the prolonged absence of other meat. It has repeatedly happened that cattle dead of the rinderpest and horses dead of glanders have been eaten with impunity. But it is essential that such meat be thoroughly cooked, and it is much safer that all the blood be drained away. Tuberculous meat and milk may affect the consumer; but it is probable that actinomycosis, a less communicable disease, is often mistaken for the former. Beef and pork infected by the measle (cysticercus) may communicate tapeworm, and trichinous pork trichina spiralis to man. The measle is observable by the eye as a small, rounded body; but it is incorrect to designate pork that is simply old and rusty as "measly," as is sometimes done. Very thorough cooking, so as to kill all the contained parasites, is necessary and the interior of boiled or roasted meat should show that this has been done. Notwithstanding that all diseased animals are not necessarily to be condemned for food under the stress of military emergency, it must be remembered that the stronger medicines used in their treatment have been known to poison persons eating such flesh. Animals with malignant pustule are always dangerous and their carcasses should not be buried, but burned. Sausages and meat pies sometimes become toxic by the development of a substance not yet isolated; and hash prepared over night in warm weather and stale mixed dishes are liable to induce intestinal disorders with marked choleraic symptoms. Fresh meat may be preserved for some time by heating the outside very strongly, thus coagulating the outer albumen and sealing the contained juices against infection from without. The external application of charcoal, sugar, or gunpowder well rubbed into the surface is also preservative. Partly prepared fresh meat may be preserved on a large scale by canning, but the use of antiseptic chemicals is apt to be hurtful. Corned beef, cooked and canned, has double the nutritive value of the same quantity of uncooked beef, and is a valuable substitutive part of the ration, at the rate of twelve ounces, where fresh beef cannot be issued. It contains sixty per cent. solids, of which forty are albuminoids, fifteen fat, and five salts. Corned beef contains six per cent. nitrogen. Bacon is the exception to the rule that cured meats are less digestible than when fresh. Its fat is more acceptable than that of pork, and it is a form of food that is easily transported and is well suited to the demands of severe exercise. From its nature it wastes much under heat. It is distasteful to those not in rude physical vigor and to most in hot climates. There are several alimentary substances not ordinarily used that necessity may lead troops to eat. Of these horseflesh, which contains more nitrogen and less carbon and hydrogen than beef, is the most commonly available. To an army in the field horses are more useful as auxiliaries than as food; but in a siege, or when not required

for their ordinary purposes, they afford a wholesome and efficient diet. A field hospital after an engagement, if at all short of meat, should certainly utilize horses killed in action.

To Cook Meat.—For boiling, the piece should be as large as possible and be plunged in boiling water to remain five or ten minutes. This coagulates the albumen in the outer layers and retains the juices. The temperature of the water should then be reduced to 160° F., as at 170° and above the meat would become hard and indigestible. The meat should remain in the water fifteen minutes for every pound of its own weight. Baking, which is not roasting, although ordinarily so called, is treating meat exactly similarly to roasting and for the same reasons, except that a dry heat is used. To roast properly the meat should be cut into pieces one or two inches square and be held for a few minutes before a hot fire, as in the field. Frying as ordinarily attempted evolves fatty acids, generally injurious, which penetrate the particles of food and envelop them in grease which the gastric juices do not dissolve and which irritates the stomach. Food cooked in fat should be drained in a sieve for a few minutes. Stewing when properly conducted is admirable. Small pieces of meat should be kept for about two hours in a little water at not far from 134° F. This partly extracts the juices, keeps the albumen semi-fluid and enriches the accompanying liquid, which must be served with the meat. Stewing is the exact opposite of boiling, in both theory and practice. Soup is made by putting uncooked meat into cold water, one pound to a quart, and heating gradually. Rapid boiling volatilizes the aroma and probably part of the nutritious matter; cracked bones increase the strength of the soup, and cooked meat may be added three-quarters of an hour after putting on the fire; potatoes thirty minutes before it is done; other vegetables an hour and a half. The essentials are scrupulously clean pot, slow cooking, and constant skimming. Stock for soup is made by putting lean meat into cold water, three pounds to a gallon, and cooking slowly for several hours. The fat is skimmed off and a jelly remains after cooking. When re-dissolved by heat and reboiled, with water and seasoning added, soup is quickly made. Such stock can easily be made in camp and carried on the march.

One marked element in the greater efficiency of the regular over the volunteer soldier is his ability to prepare his food and to assimilate it, to avoid waste without and within the body. The civilian who has depended upon trained cooks and domestic conveniences, in the field wastes the raw material in trying to dress it and cannot digest and appropriate much of what he eats. "An army moves upon its belly," and to teach each recruit and militiaman the practical use of the army ration would render him more valuable as a fighting man than would any amount of rhythmical movement in a manual that is never executed under fire, or perfection in establishing an alignment that can never be preserved in battle. Hence at the militia camps of instruction caterers should not be permitted, and the men should be taught and exercised in the principles and practice of the simpler cooking. In permanent garrisons of organized troops messes of more than one company should be forbidden, as having a direct tendency to render men helpless in emergency. The garrison mess is an agency that lessens the responsibility of the company officers, diminishes the interest of the men in a most important part of their company organization, and fosters ignorance of the very features by which their success in the field in maintained. It would be an economy of energy and of material for each militia company to employ a good cook as instructor in the use of the army ration during the summer encampments; but details of men should be required to do the work and they should be made to understand that duty in the cook-house, however distasteful, is quite as honorable and is of more value than some of the showy exercises that would otherwise occupy their time. When its importance is explained, the public spirit that inspires the better militia regiments, a patriotic sentiment which cannot be too highly commended and which is the essence of their usefulness as public bodies, would soon enable the citizen soldiers to bear this burden in common with other trials that are necessary to make them efficient in the field. Then they may in campaign justify the sacrifices already made, and not fall ignominiously into the ranks of the non-effectives because they have neglected this inconspicuous but essential preliminary.

Newly organized regiments require careful oversight and instruction in the care and preparation of their food from the very first. A recruit has enough physical ills to contend against to make it of the first importance that his bodily strength should not be impaired by an imperfect or hurtful diet. The law requires that "the line officers of the army shall superintend the cooking done for the enlisted men" (Rev. Stat., 1234), and "the officers of the medical department of the army shall unite with the officers of the line in superintending the cooking done by the enlisted men" (Rev. Stat., 1174). It is not expected nor is it practicable that these officers shall minutely instruct in cookery, but they should have a knowledge of the general principles of that art and, especially with new troops, should promptly interpose when there is a suspicion of deficient quantity or deteriorated quality. A sudden increase of the sick report in the direction of gastric and intestinal complaints, especially if limited to distinct subdivisions of the command, requires the medical officer carefully to examine the kitchen and the table. Beans imperfectly cooked, potatoes not thoroughly "done," a cheap grade of molasses bought through mistaken economy outside of the Subsistence Department, are among the common causes of such trouble. Any food undergoing fermentative change is likely to do harm. All these conditions are directly within the domain of preventive medicine, that is, of hygiene.

Besides the bread and meat already discussed, which are the essentials of every ration, vegetables are liberally supplied to United States troops. Beans when properly cooked are admirable food; when improperly cooked they are said to be more disabling than the enemy's fire. They contain more than twice as much nitrogen as bread and supplement it admirably. But they require to be soaked at least twelve hours and to be boiled slowly until tender, which requires two or three hours more. They should not be boiled in hard water, for the lime salts render the legumin insoluble. No amount of boiling will soften old beans. They should be soaked twenty-four hours and then be crushed and stewed. But if lime water must be used for cooking beans, a certain amount of the lime may be precipitated by preliminary boiling, after which the supernatant water carefully poured off may be used. The difficulty in cooking beans increases directly with the altitude of the place.

Fresh vegetables, now a liberal part of the ration, are always desirable as food, to stimulate the appetite, and probably to assist the digestion and assimilation of other food. They are especially valuable as antiscorbutics, but partly on account of their perishable nature and partly from their bulk they are difficult to issue in campaign or under adverse conditions; that is, just when most needed there is the greatest risk of failure of supply. Potatoes on account of their starch are an excellent addition to bread and, properly cooked, are always appreciated. The tomato, on account of its malic acid (0.3 per cent. free and as much combined with bases), is a better antiscorbutic than the potato. No savings from fresh vegetables are purchased by the Subsistence Department. The shrinkage in cooking vegetables is about ten per cent., exclusive of waste. Desiccated vegetables do not appear to have the practical value that theory would indicate, but they are not to be rejected when the fresh are unattainable. To secure tomatoes canned without the present excess of water would be most acceptable, and is an aim worthy of the utmost effort. In receiving canned tomatoes it should be remembered that the two- and three-pound cans of commerce fall short of their nominal

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weight, so that the aggregate deficit where large quantities are involved is considerable.

Cheese.—Cheese is no longer a part of the ration, but it is well adapted to the mess-table as an occasional purchase. When well masticated it is not indigestible, as popularly supposed, and it is a nutritious and concentrated food of which a half-pound contains as much nitrogen as a pound of meat, and a third of a pound contains as much fat. But cheese decomposes readily so that it is not easily kept, especially in hot climates; and an obscure fermentative change sometimes develops an active gastro-intestinal poison (tyrotoxicon) in cheese which appears sound. This yields no peculiarity of appearance, odor, or taste; but it may be detected by a strip of blue litmus paper pressed against it suddenly turning red. The poison is volatile in boiling water; therefore poisonous cheese may be safely eaten after being cooked.

Canned Foods.—These sometimes ferment, and they should be rejected when bulging of the end of the can shows the pressure of gas. The inspection of large contracts should be very rigid, because the temptation to supply inferior goods is very great. The cans should be resistant, and should have both the name of the factory and of the dealer on the label. A fictitious factory name or no dealer's name is a sign of doubtful goods. A rosin flux to seal the cans is better than one of zinc chloride, which now is more common. When carelessly used the rosin may harmlessly affect the taste; but the zinc labors under the charge, not yet proven, of injuring the health. It is possible that hermetically sealed food, when kept for a long time, especially under either extreme of temperature, may deteriorate. The actual weight and the nominal weight of cans as sold frequently are not the same. The War Department officially estimates the contents of certain trade packages as follows: So-called one-pound cans of baked beans, $10\frac{1}{2}$ ounces; three-pound cans, $34\frac{1}{2}$ ounces; two-and-one-half-pound cans of tomatoes, 2 pounds; three-pound cans at $2\frac{1}{4}$ pounds; gallon cans, $6\frac{3}{4}$ pounds.

Concentrated Food.—There has been a constant effort to arrange a condensed ration that will supply much energy in a small bulk, and new emergency rations are frequently devised. It remains true, as set forth by Parkes, that for constant work a man must consume at least from 260 to 350 grains of nitrogen and from 8 to 12 ounces of carbon in the twenty-four hours, which are not yet available in a less bulk than 22 or 23 water-free ounces. Life and vigor can be sustained for a few days on less, although with some loss of weight, and thus concentrated food may be used for a few days. Eleven ounces a day is the minimum amount and one week is the maximum period of safety. They develop a certain amount of force, but they supply tissue waste in a very limited degree, so it is quite necessary for troops that operate under their spur to rest and replenish when the dash is over. They are not organic magazines for the supply of material, and they must be supplemented by sleep and the carbohydrates. Those directing their use must be made to understand that concentrated foods, like high explosives, have strict limits to their fields of usefulness. The German pea sausage, which is probably over-rated as a constant diet, consists of pea flour, fat pork, and a little salt. It is issued cooked and makes soup readily. The original United States emergency ration practically consisted of a full day's allowance of hard bread, bacon, and coffee with four ounces of peameal for soup-making and a little tobacco. It has been experimentally shown that five days' such rations will maintain men actively occupied for at least ten days with trifling loss of weight. The food elements are rather more than required for a mere subsistence diet, and the reserve energy of nature must be drawn upon to supply the draft made by unusual exertion. A new emergency ration has been prepared, as explained on a previous page, and is about to be issued. Repeated trials with moderate bodies of troops have approved it, but it has not yet been tested on a large scale. It is probable that the most valuable of all truly concentrated preparations is Liebig's *extractum carnis*, now made in many places. It is not strictly a food, but is rather a nitrogenous stimulant, whose office is to urge the heart and remove the sense of fatigue. It would be an important special issue to pickets and to all troops after prolonged exposure. It is often the case that the conditions of rapid marching, of severe fighting, of bad weather, in short the rougher aspects of military life, are those which, at the same time that they develop the necessity for food, limit its supply to what the troops have upon their persons. When most needed, the supply trains are apt to be the farthest away. If the beef extract, or something analogous, could be issued in suitable packages to the men individually along with the extra ammunition before an impending engagement, those who could be induced to preserve it until after the battle would have at hand a most valuable restorative. Such a method would secure for the wounded a wide distribution of food at precisely the most important time. The medicinal use of kola certainly greatly lessens the sense of fatigue and extends the limit of muscular exertion. It is commended for use by medical officers with a marching column to assist those liable to break down from over-exertion, but it should not be put in the hands of the troops for indiscriminate employment.

A great deal of recent discussion has taken place upon the character of the ration adapted to the tropical countries, having specially in view our southern borders and our insular possessions. Much of this is due to confusion between the food allowed and the food consumed. As herein explained, the allowance of food is liberal and widely alternative, and when the substitutions which the local conditions permit are made it is believed that not only no sickness will be found directly due to the diet, but that, as far as food is a factor, the health of the troops will be maintained by it. The only recent change or addition of importance has been an increased allowance of sugar, for an excess of which there was a spontaneous general call. It is probable that the excessive use of starches to the exclusion of flesh among the Asiatic races is primarily due to financial considerations and secondly to inherited peculiarities. Certainly it would be very unwise suddenly to impose upon white troops from temperate regions a diet identical with that of the natives of the tropics, merely because they have been transferred thither for military duty with no prospect of permanent residence. A surfeit of meat is likely to produce more harm in the tropics than at the north, but there is no probability of surfeit in military life.

Antiscorbutics.—Bodies of men, afloat or ashore, are prone to be attacked with scurvy when deprived of fresh vegetables for a length of time and especially when fed upon salt meat.

Mental and moral depression engendered by military reverses and by monotonous lives under conditions of isolation have a predisposing tendency, and it is certain that scurvy itself exerts a disheartening influence on the men's spirits. Constant entertainment and physical amusements should not be overlooked as hygienic precautions against this disease. The diagnosis of scurvy will be found in the appropriate article, but it may not be out of place to warn the inexperienced officer that it frequently simulates muscular rheumatism at the beginning, and is liable to be mistaken for the simple effects of exposure to cold and wet. Night-blindness coming on in a man whose vision has heretofore been good points toward scurvy. Scurvy is presumed to be due to the want "of the salts of citric, tartaric, acetic, and malic acids, and of the acids themselves." Their use prevents it, and the eaters of fresh meat generally escape. It is uncertain, however, how far those who are supposed to be exclusively eaters of fresh meat, as the hunters and scouts of the plains, owe their immunity to the vegetable matter that they probably devour as occasion offers without looking upon it as formal food. Pemmican, a combination of the best beef pulverized, fat, sugar, raisins and currants, is a particularly nutritious antiscorbutic for cold climates, and is in great vogue with Arctic trav-

ellers. The juice of lemons and limes is both a preventive and a remedy, and should always be in store for issue to troops likely to be long on transports, as it is to ship's companies, as well as to those exceptional stations where soldiers are completely cut off from the supplies of fresh vegetables. Unadulterated vinegar has much virtue, and it has been suggested that the tradition that Hannibal made a way for his troops through the Alps with vinegar refers to preserving their health in those frozen wastes by its use. Generally speaking, fresh succulent vegetables and fruits fill the need; but of these the seeds are the least useful parts, and the Leguminosæ have no virtue. The tomato, the raw potato, and the onion are practically the most valuable of the common vegetables. Fresh cabbage is better than sauerkraut. Raw potatoes peeled and sliced and covered in alternate strata with molasses keep well and are antiscorbutic. The yellow mustard and the cresses eaten raw; the young shoots of the pokeberry (phytolacca decandra) as a vegetable; the lamb's quarter (chenopodium album), and the dandelion (taraxacum) as a salad or boiled as greens, should never be neglected. Of these the lamb's quarter is peculiarly grateful and is reasonably common. All the varieties of cactus, a very widely distributed genus, are efficacious and do not seem to be properly appreciated by our troops. The spiny tough skin torn off after action by fire yields a succulent interior, not very palatable but always useful. The tall varieties of cactus contain valuable juice to be obtained by tapping. The best antiscorbutic is the agave (American aloe). The leaves should be cut off close to the root and be cooked well in hot ashes, after which the juice should be expressed. This may be taken raw or sweetened, two to eight ounces, three times a day. The white interior of the leaves may be eaten. The agave is both preventive and curative, and no pains are too great to procure it when needed. In Mexico pulque from the agave Mexicana is similarly used.

Beverages.—Water, discussed in another volume, is the base of the ordinary drink of soldiers. It is enough to say here that water contaminated with appropriate poisons will certainly convey typhoid fever, dysentery, cholera, and kindred diseases, will probably communicate diphtheria, and it is not yet disproved that the malarial plasmodium may be thus introduced. The source of the water supply must therefore be carefully investigated and where possible protected. Besides the active physiological poisons just indicated, there are mechanical and chemical vitiations to be avoided. As the exigencies of the service often compel the use of impure water, there are two points especially to be impressed upon all officers and men. The first is that much water which is acceptable both to the sight and to the taste is unhealthful, and secondly that the boiling of such water will reduce that risk to the minimum. The bacterial causes of disease as found in water may be quite destroyed by brisk boiling, continued for a short time. Distilled water is necessarily free from them, unless introduced after condensation. But boiled or distilled water is flat to the taste, and it may be made more acceptable by the simpler methods of aeration, such as pouring it repeatedly from one vessel to another, or by the use of a churn. On a large scale air may be forced through under pressure, and it may be charged with carbon dioxide by special appliances. Too much stress cannot be laid upon the importance of boiling the water in the presence of water-borne diseases. Under proper discipline this can always be effected in garrison, and there have been remarkable instances where under very difficult conditions marching troops have succeeded in boiling all their drinking-water and have remained free from disease that attacked a companion column.

The inorganic substances held in solution that are the most common are the alkalies soda, potash, and magnesia, as found on the great plains and elsewhere. They seriously disorder the digestive apparatus or are so intense as to render the water undrinkable, and as far as known can be removed only by distillation. And that cannot be carried out on a large scale, because of the lime and other salts clogging the boilers. The ordinary "hardness" of water depends on the bicarbonates of lime and magnesia in solution and on free carbon dioxide. When such water is boiled half an hour the carbon is dissipated and the bicarbonates are transferred into simple carbonates; which being insoluble are precipitated. The temporary hardness is thus removed and the permanent hardness, due to soluble lime and magnesia compounds, usually sulphates which cannot be extracted, remains. On a large scale the addition of lime subtracts a certain amount of CO_2 from the soluble bicarbonate of lime and precipitates it into one insoluble carbonate (Clark's process). Besides the dissolved foreign matter, water often contains both organic and mineral substances in suspension, toward which the most of the processes of clarification and filtration are directed. The most of the insoluble particles of slightly greater specific gravity than the water itself, which make water muddy, usually fall to the bottom when the water is at rest, and this sedimentation on a small scale is often sufficient for domestic use. On a large scale settling basins are important adjuncts to reservoirs. A more rapid process to make water potable by removing diarrhœa-causing turbidity is the use of alum, especially if the water is hard. About six grains of crystallized alum to the gallon slowly dissolved forms calcium sulphate, which with the bulky aluminum hydrate entangles and carries down the suspended particles. Very soft water requires first a little calcium chloride and sodium carbonate. Chopped cactus leaves clarify muddy water, and citric acid, half a drachm to the gallon, acts upon algæ in water. The disagreeable odor of impure water in casks may be removed by the gradual addition of Condy's fluid (solution of permanganate of potassium), until the slightest permanent pink is obtained, and of six grains of crystallized alum to the gallon. Suspended matters, dissolved organic matter, and bacterial organisms may be removed by filters. Sand filters, costly in their construction and care, are the best for large communities but are not adapted to military establishments. Ordinary filters for the house supply of cistern water should be arranged for percolation upward through gravel and then sand, after the water has passed through a settling basin for the deposit of coarse sediment. Portable filters equipped to restrain the impurities mechanically are generally not efficacious. Animal charcoal, formerly much used, is objectionable in yielding phosphates and nitrogen, which favor the growth of bacteria in water. Putrefactive organic matter is oxidized, but that which is active passes through unchanged; so that the filtrate soon contains more germs than the unfiltered water. Vegetable charcoal filters against micro-organisms when fresh. Sponge, cotton, and wool acting mechanically soon become foul. The best filter for domestic use is unglazed porcelain through which the water passes at moderate pressure, but as the bacteria will ultimately grow through the kaolin the bougie must be carefully brushed and boiled at least once a week. In the form of the Chamberland-Pasteur this is supplied in the military service to sterilize water whose gross impurities have been removed by the Berkefeld filter. But a cardinal principle which can never be overlooked is that no filter is automatic in its renovating power and all gradually deteriorate. Therefore every part of the apparatus must not only be accessible but be systematically and frequently cleansed, or the water may become fouled by the very effort to purify it. For the field one barrel pierced near the top may be enclosed within another pierced at the bottom and sunk in the water-supply, with the intervening space filled with sand or gravel. Whatever action is taken with water after it is drawn, one of the first duties in establishing even the most temporary camp or halting place is to establish a guard over the water-supply, to see that the animals drink farther down stream if there is running water, or at another pool, and that all bathing or washing be conducted below the drinking places. If the supply is small, great pains

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must be taken to husband it and to see that it is not made turbid. It may be increased by digging out a small spring and sinking a barrel, and in a shallow stream a small reservoir for drinking should be made by a temporary dam, with one below for horses, and still another for washing. One or more reservoirs should be made to retain for cooking and drinking the water that flows by night, and there should be rows of sunken half barrels connected with little gutters for the horses, with a still lower reservoir to collect the waste. Horses drink best and most rapidly when the water is at least five or six inches deep. Nothing is better established than that no refuse, and especially no fecal matter, should be discharged so as to follow a stream either directly or indirectly, unless it be a great river; and then only when it is certain that no one within a reasonable distance will use from it. It is suicidal to pollute small streams that may possibly supply our own forces then or later, and it is criminal to spread disease in that way among others. When the supply is from springs or wells the latrines should be carefully placed so that no drainage, either by proximity or through the dip of the strata, could enter them. Sodium bisulphate, fifteen grains to the pint, will sterilize water as against the typhoid-fever cause, so prevalent in the field (L. Parkes and Rideal). The rule is general that in ordinary soil the bottom of a well may be considered the apex of an inverted cone whose radius is equal to its depth, all of whose contents drain inward. In sand the area drained is very much greater, and in some rocks faults, the direction of the strata, and, notably in limestone formations, crevices will conduct fluids very long distances. Contaminated water is not necessarily disagreeable, and that containing animal waste is apt to be more sparkling and may be very acceptable. Wells sunk in a river bank draw the most of their supply from the subsoil water going toward the stream, hence great care should be taken not to intercept that soaking down from a contaminated site. Where rain water is depended upon, it may be important to determine the quantity available from a non-absorbent surface. This is found by multiplying the inches of rainfall by the square inches of area, and the cubic inches of rain thus obtained may be divided by 1,728 for cubic feet or by 277.274 for gallons. The amount of water required on the march for a man for drinking and cooking is six pints, increased in hot climates to eight pints, with an equal amount for ablution. In stationary camps five gallons are required for all purposes. In barracks ten gallons will be used where there are no sewers, and twenty-five where there are water-closets and baths. For permanent hospitals fifty gallons per head should be allowed daily; and all these may be regarded as minima figures. Horses will drink from six to ten gallons a day and require about three gallons for police purposes.

Ice.—The sources of domestic ice-supply should be as carefully protected as those of water, for freezing is but an imperfect means of purification and bacteria are especially apt to be entangled in snow-ice and in that holding air bubbles. Artificial ice not made from distilled water may be very impure. Those in control should be carefully taught that polluted water is practically without remedy, so that the only safety consists in keeping the water-supply inviolate.

Coffee.—Soldiers in garrison appear to like coffee best when it is not very strong and the volume is great. Such use of hot drink should be encouraged, for it insures the water being boiled. In winter the heat is a stimulant without reaction, and in summer it supplies without risk fluid lost by perspiration. The men often like it adulterated with chicory and with so-called coffee extract. This is well enough in garrison where there is no special strain, for the chicory is harmless and the ordinary coffee "extracts" appear to be innocent compounds of liquorice, sugar, and possibly small amounts of some artificial flavoring. The advantage is that the ration thus supplies much more warm fluid. In the field reliance should rest only upon the coffee itself. Its physiological effect is that of a nervous stimulant, with probably a tendency moderately to delay tissue change. The so-called concentrated coffees are not looked upon with favor, probably containing little real coffee. The disadvantages of coffee in campaign are its bulk and the liability of the roasted and ground berry to accidental loss and damage.

Tea has much the same physiological action as coffee, but its flavor is not so acceptable to most American soldiers. It lends itself very admirably to campaign purposes, being easily carried in small bulk—a stout flat glass vial is an admirable vessel—but it is not a popular drink. The behavior of the contained tannin with iron utensils makes it very distasteful.

Chocolate, not a part of the ordinary ration, is nutritious and palatable when properly prepared. But this can rarely be done in the field, and it is too costly for the ordinary garrison diet. It is a part of the emergency ration.

Alcohol, in all its forms, is only mischievous to the soldier. Formerly a daily dram of ardent spirits was regarded as essential for soldiers and sailors, and as late as 1865 whiskey was kept by the Subsistence Department for special issue as preservative of health after great exposure and fatigue. These regular and special allowances were made because of the general belief, and the almost universal earlier practice among civilians, that under ordinary exposure, to say nothing of extraordinary fatigue, "strong drink" so-called was required to support those doing hard work. Strong drink seems to have been regarded as the complement of strong meat, and the few who did not use it were thought to deny themselves proper care. In fact in the first half of the nineteenth century British life companies discriminated against total abstainers as undesirable risks. But all insurance statistics now show that abstinence from alcohol increases the expectation of life. Alcohol comes fairly within Headland's definition of a narcotic, as a "medicine which acts first to exalt the nervous force and then to depress it, and to have also a special action on the intellectual part of the brain." Intoxication is a semi-narcotic condition with physical and mental want of coordination, and the "exhilaration and stimulation are stepping-off stones in the order of progress to narcotism." But alcoholic drinks have further effects. Pure alcohol constricts the blood-vessels, restricts and arrests the movements of the blood globules, destroys the circulation, and causes sloughs. Diluted alcohol as spirits is quickly absorbed after food, enlarges the blood globules, increases the volume of the blood through its affinity for water, dilates the capillaries, quickens the heart's action, accelerates the respiration, and drives the blood more quickly through the lungs. Considered by itself, and particularly when administered under conditions of depression where natural reaction is not to be expected, a small quantity of diluted alcohol may be taken occasionally without harm. But drank ordinarily or without physiological necessity, from artificial desire or the mere habit of drinking, it works mischief. The quickened circulation already described is accompanied by the subjective feeling of greater warmth, which is real in a very moderate degree and for a very short time, depending upon the primary dilatation of the capillaries. But that very condition speedily cools the blood by exposing it to the atmosphere through the lungs and skin, and by increasing the evaporation through stimulation of the sweat glands. Hence one under the influence of alcohol loses the power of resistance to cold, and not only the drunkard but any one drinking perishes from such exposure more quickly than the sober or the abstinent. But for a person greatly reduced and without oleaginous food in an excessively low temperature spoonfuls of spirits carefully served are invaluable. Nevertheless the subsequent depression leads to harm, and such treatment cannot be permanently depended upon. Under the habitual use of alcohol the soft and vascular tissues suffer first. There are congestions of the digestive tube tending to hemorrhage, the liver is soon disturbed, and the repeated distentions lead to congestions, to inflammation, and by

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the increase of connective tissue often to cirrhosis, notwithstanding that the experiments of Dujardin-Beaumetz upon pigs seem to show that cirrhosis is not thus produced in them readily. In the military service, however, whiskey drinkers generally break down from other causes before the cirrhotic condition is reached. Gastric catarrh is set up and imperfect digestion follows the excessive use of whiskey; the nerve cells are distinctly changed and atrophied and the neuroglia is increased; the heart's action is habitually hurried, a sign of weakness; the heart muscle becomes fatty, and the arteries become atheromatous. The more intoxicating drinks do the most mischief, but they are not harmful in proportion to their strength but to their free acids and volatile oils, which depend upon the substances from which they are derived. In the modern destructive distillation at high temperatures these oils are thrown off in excess. Fusel oil is one of the most hurtful of these, but it partly evaporates with age if the spirit is not held sealed in glass. It is probable that it is an excess of fusel oil that makes the "vino" of the Philippines such a peculiarly pernicious beverage.

The physiological and pathological statements just made as to the action of alcohol as found and used in daily life may be accepted as actual and controlling facts, notwithstanding that laboratory experiments with the living man warrant the assertion that within narrow limits alcohol is academically a food. It is partly oxidized in the blood, is transformed into acetic acid and alkaline acetates and then into carbonates, and it retards tissue change (Yeo). These features give it the character of food. But a part is always eliminated unchanged through the kidneys and the lungs, and in excess of very small amounts it is invariably hurtful. One ounce of brandy or whiskey freely diluted is the extreme quantity that may be taken at one time without risk of depression, and twice that amount within twenty-four hours is the maximum for a healthy man. A very wide difference exists between the results of undisturbed experiments under artificial conditions and the experience of daily life. The habitual use of alcohol, in any form or to any degree, is no more necessary for the ordinary man of twenty-five than it is for the lad of fifteen, for whom no one would think of advising it. Like any other medicine, its employment in health only results in disturbing health.

Malt liquors are frequently regarded as innocent, if not directly strengthening. They do contain nutritive material useful for a certain class of invalids, but not for persons in such health as soldiers are supposed to possess. "They produce plethora, and habitual excess of this overtaxes the organic, and weakens the conservative powers; so that the florid countenance and fatness of persons addicted to fermented liquors are suspicious evidence of a constitution taxed to the highest, and constitutional predispositions that might not have been aroused are frequently excited into activity." But beer contains only about three per cent. of alcohol, as compared with forty-two per cent. of brandy and whiskey.

But there is always a practical as well as a theoretical side to this subject. Without hesitation ardent spirits are to be condemned as a beverage and their use as such discouraged in every possible way. But beer presents a different problem. For several years the post exchange, a happy substitute for the old trader and the older sutler, has sold under supervision beer in moderate quantities to enlisted men. The unanimous testimony of competent observers has been that the garrisons have become more temperate, that the troops have been more contented, and that both minor and major offences against discipline have been fewer when the sale of beer has been authorized as an incident of the soldiers' refreshment rooms established under the above name. The reason is that the recruits and older soldiers, although required to be of good character when enlisted, are not as a rule from a totally abstemious class. The most of them have been accustomed to drink beer, many of them to occasional indulgence in spirits. When no drink of either kind is to be found on the government limits they are easily enticed, especially after periodic pay-days, to the low-class saloons that spring up just off the reservation. In them it is no exaggeration to say every unfair as well as legitimate inducement is offered to acquire their money in exchange for bad liquor and the concomitant opportunities for vice that flourish in such resorts. As a consequence unauthorized absence, defiance of orders, disorderly conduct away from and upon the reservation, arrest and punishment frequently by both civil and military authorities, physical injury, sometimes serious, sometimes fatal, and disease, often long continued and deplorable in its consequences, followed. The saloons just beyond military control were a constant annoyance and a menace to the good order of the garrison, and ruined men who otherwise would maintain a reputable character. The sale of beer in the posts, the profits from which in common with the other profits of the establishment went to increase the variety and improve the quality of the soldiers' mess, satisfied the desire of most men who cared to drink (for, contrary to the opinion of some, the average regular is not a drunkard, because drunkards cannot remain in the military service), the practice of treating was not allowed, the quantity sold to any man at any one time was carefully regulated, there was small temptation to stray away in search of alcoholic excitement, the bar was distinct from other parts of the exchange, and the liability for a non-drinking man to learn to drink was less than one of a similar class would have at his home. Unfortunately legislation has recently (1901) abolished this feature of the exchange, and in an effort to improve the habits of the enlisted men it has gravely damaged the prospect of true temperance among them. The writer believes in the theory and the practice of total abstention from alcohol for all men, civil as well as military, as leading to their greater efficiency and assisting in the elevation of character; but he recognizes that such a change in the mode of life in those accustomed to occasional drinking cannot be effected at once nor by the exercise of authority, where opportunities which cannot be suppressed abound for greater indulgence. This expression of opinion is made in the hope that it will assist in forming an intelligent judgment in aid of the true elevation of the enlisted man. With the reservation just expressed in favor of allowing the moderate sale of malt liquor to those accustomed to it, as an evil much less than that of leading them into the temptation of stronger drink with its associated perils, it is not necessary to insist from theoretical or medical grounds alone upon the mischief that alcohol causes soldiers. The observation of any officer of experience is enough. Liquor, besides weakening men physically, tampers with their will power, disturbs their temper, makes them less trustworthy even when sober, is at the bottom of almost every violation of discipline, and is the one agent that converts a regular force into a mob. The absence of liquor usually means a clear guardhouse. Abundant liquor means a heavy sick-list, a large guard report, and a general feeling of doubt as to the command. As the popular prejudice that a soldier is of necessity a drinking man, if not a drunkard, is one of our direct inheritances of English vice and stupidity, although I am free to affirm that our regular troops of late years have been far and away more temperate than the majority in the class of life in which they were recruited, it is proper to lay emphasis upon these convictions of Parkes, the great military sanitarian, who reached them after long years of observation of the most drunken army of the world and a careful review of the whole subject: "When debarred from spirits and fermented liquids men are not only better behaved, but are far more cheerful, are less irritable, and endure better the hardships and perils of war. The courage and endurance of a drunkard are always lessened; but in a degree far short of drunkenness, spirits lower, while temperance raises, the boldness and cheerfulness of spirit a true soldier should possess." He asks: "Are there any circumstances in a soldier's life in which the issue of spirits is advisable, and if the question

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at any time lies between the issue of spirits and total abstinence, which is the best?" He answers: "If spirits neither give strength to the body nor sustain it against disease—are not protective against cold and wet, and aggravate rather than mitigate the effects of heat—if their use, even in moderation, increases crime, injures discipline, and impairs hope and cheerfulness—if the severest trials of war have been not merely borne, but most easily borne without them—if there is no evidence that they are protective against malaria or other diseases—then the medical officer will not be justified in sanctioning their issue under any circumstances." I cannot refrain from a final quotation from the same great authority, a quotation perfectly apposite, because civilians, with their inbred personal habits, are the stock upon which military methods and military virtues must be grafted and cultivated in the army, and are the reliance of the nation in a great war. He says: "It is the same thing in civil life; there is no question that more disease is, directly and indirectly, produced by drunkenness than by any other cause, and that the moral as well as the physical evils proceeding from it are beyond all reckoning; and yet the attempts of the legislature to set some bounds to intemperance have been, and are, opposed with a bitterness which could only be justified if the degradation, and not the improvement, of mankind was desired." I can add nothing to the solemn weight of Dr. Parkes' opinion, which cannot be too frequently repeated nor too well learned and practised by every man who wears a uniform. It follows that if the use of alcohol is hurtful in a personal and in a martial sense to the private soldier, who is the first unit in the military scale, it is very much more mischievous in its ultimate consequences when an officer, who is so potent with those beneath him, is its victim.

HABITATIONS.—*Sites.*—As a rule soldiers live in barracks or tents supplied by the Quartermaster's Department. It is seldom necessary that a permanent post should be established on a directly unhealthy site, and a proposed locality should be carefully examined, especially as to the air and water in the soil as well as in relation to the condition of the adjacent country. The ground air is air that is always found in the soil above the level of the ground water. It is constantly in motion vertically and laterally, and is forced upward by a rise in the ground water or is drawn by aspiration into heated dwellings. It follows that sites charged with organic matter and especially those upon impure "made soils" are to be avoided, and it is better to exclude all subsoil air from dwellings. This factor, which is not readily recognizable by the senses, deserves more consideration than it generally receives. The soil is moist when it contains water as well as air. Ground water is defined by Pettenkofer as that condition in which water fills all the interstices of the soil, forming, except as separated by the solid soil particles, a continuous sheet of water. As Parkes points out, the soil becomes moist by absorption of rain water, by the rise and fall of the subterranean water-sheet, and by evaporation and capillary attraction from that surface. Soil moisture and ground water are distinct conditions, the latter being relatively low and the other in the levels reached by the air. Practically every soil contains at some depth a constantly moving body of ground water, which, like the ground air above it, varies in the rate and the direction of its progress. Soil moisture depends upon the relative proportion of air and water. Moist soils are associated with catarrhs, neuralgia, rheumatism, the paroxysmal fevers, and notably with consumption, and should be avoided if possible. If compelled to build upon them, they should first be dried by deep drainage and by attention to the surface drainage. The removal of a few inches of the surface soil, and the substitution for it of a mixture of quicklime and dry ashes, is an advantage. Military necessity sometimes compels camps to be pitched in unsanitary positions, and proximity to water-supply often controls the choice. Very little camp labor is more profitable than that of ditching, which should never be neglected; for the place selected for the camp of a night may be occupied for weeks.

Topographical Sites to be avoided are enclosed valleys, ravines, or the mouths of ravines, any ill-drained grounds, the neighborhood and especially the lee of marshes, the northern side of mountains or high hills, and in warm latitudes, in the northern hemisphere the northern banks of rivers. *Soils* to be avoided are those that hold moisture. Granite and metamorphic rooks are usually healthy and so are clay slates, but with the latter drinking-water will be scarce. Unless dominated by adjacent heights, deep gravels are always healthy, and gravel hillocks are the best of all sites. Sand when pure and deep is healthy; but such a site soon becomes charged with refuse whose air and water pass through it laterally as well as vertically. When clay underlies dry sand, water is apt to be held and to be harmful. Clay and alluvium are generally suspicious from the contained moisture, but well-cultivated soils in the vicinity, rice-fields excepted, are acceptable.

Vegetation upon Sites.—For camps as well as for more permanent posts, brush and undergrowth may be cleared for convenience as well as because they favor dampness; but speaking generally trees should not be disturbed except when, by cutting off light and air from a domicile, they are hurtful in that they make it dark and damp. Rank vegetation should be cut in the heat of the day and be burned before decaying, but neither the heavy brush near a marsh nor the soil itself should be disturbed. Belts of trees and tall shrubs at some distance are acceptable as barriers against malaria whether mosquito-borne or conveyed otherwise, and trees in plantations break cold winds in cold climates and cool the ground in hot climates. The eucalyptus, which grows only in a frostless climate, rapidly drains the ground by absorbing the water through its roots and dissipating it by evaporation. Its aromatic odor is particularly distasteful to the mosquito, and malarial disease rapidly lessens where this tree grows. In colder climates the growth of masses of sunflower, by absorbing the moisture and perhaps by interfering with the flight of the mosquito, has been followed by diminished malarial disease.

Barracks.—The essential conditions of barracks, besides healthful sites, are a reasonable temperature in relation to the seasons, light, dryness, and an adequate air-supply within the buildings. Casemates, sometimes used for the artillery, are dark, damp, ill-ventilated, and unsuited for residence except under the stress of war. When permanently occupied their sick-list shows a contrast with that of better structures. Many of the other troops have lived in buildings lacking one or another sanitary essential, but as the newer barracks are generally receiving intelligent supervision it is unnecessary to rehearse examples of the vicious construction formerly so prevalent. But however well planned no apartment should receive more inmates than its sanitary number, which should be conspicuously painted upon the doors. There is a constant temptation to overcrowd, because the evils of sanitary overcrowding do not appeal to the eye; and when the command is increased the medical officer should be alert to invite attention to the proper complement of the room and to the unwisdom of attempting to require two bodies (or major fractions thereof) to occupy the space of one. The building should be suited to the climate. In the United States the adobe (sun-dried brick) makes for the relatively rainless regions houses warm in winter and cool in summer. Where the country is heavily wooded, the primitive log-house is better than one of sawn timber, which is almost sure to be unseasoned and consequently too open. Brick, which generally costs most at first, is in the end the cheapest, always on the condition that more quarters are built as the garrison increases, not that more men shall be crowded into the existing brick house. Barracks should take advantage of the full flood of the sunlight and of the southerly winds, by facing north and south; they should not throw one another in shadow, or intercept the natural movement of the air; and while they should be placed with due regard to military convenience

in relation to ground for assembly and drill, there is no reason to maintain in the modern cantonments and posts the traditional hollow square, which is a quasi-defensive arrangement the relic of the blockhouse and the primitive fort. Parkes advises the long axis of barracks to run north and south, so that the sun's rays may fall on both sides of the ridge. But this does not seem necessary in the simple quarters now under discussion, where the sunlight should pour through the windows as here suggested. In hot climates, at home or abroad, the buildings should be raised a few feet on piers to allow the air to circulate freely under the floors, and they should have broad verandas. Where there are cellars, especially when higher ground is near, the foundation walls must be protected by blind drains lower than the bottom of those walls, through which the intercepted water may be drawn off. Cellar walls laid dry or only slightly pointed on the inside are liable to dislocation by water entering and freezing. Underground foundation walls should be laid in mortar of cement and sand and, unless drained on the exterior, the outer space should be filled with gravel to conduct surface water down into the soil, if that is porous. If the soil is not porous, the bottom of the wall on all sides should be drained. The outside of every foundation wall made of sandstone, soft limestone, or brick should be coated with melted tar for water-proofing, and, besides, a damp-proof course should be introduced to check the upward capillary movement of moisture. In other words, no pains is too great in the estimate of health to secure dry dwellings. In our insular possessions troops will be quartered for a long time to come in permanent public buildings erected for other purposes but appropriated for the time by the military arm, in a few wooden Spanish barracks, or in temporary newly constructed one-story barracks of bamboo and nipa. It is particularly desirable that in all of these the men should sleep well above the ground. Where tropical barracks are constructed the roof should not be flat, unless it is double with ample air space, and there should be wide verandas. The most important room in the barracks is the dormitory, which is usually called the squad-room, and in it the men pass the most of their time while indoors. Unlike some foreign armies, our men have separate dining-rooms well equipped with attractive table ware. The newer quarters also provide a reading-room as a place for quiet assembly free from lockers, beds, and gun-racks. The minimum allowance of space per man in the squad-room is fifty square feet floor area and six hundred cubic feet of air. South of 36° North in the United States these figures should be seventy and eight hundred, and in the tropics men require from seventy-five to one hundred and fifty square feet and from fifteen hundred to three thousand cubic feet. In calculating the air space, allowance may be made for a certain percentage of inmates constantly absent in the hospital, on guard, in confinement, detached, and the like; but the floor space should be estimated in relation to the actual number of bunks (cots) allowed, regardless of their average occupation. Where the squad rooms are heated by coils containing steam or hot water, as is the case in some of the newer barracks, these should not be placed along the wall, because the radiation would be intenser near the heads of the sleepers instead of nearer their feet. It is a common error to make the squad-room too wide. More than twenty-four feet in width renders it more difficult for the sun to penetrate everywhere and for the air to be completely changed. The walls should not be less than twelve nor more than fourteen feet high. Where ordinary dwelling-houses are taken for temporary quarters, their capacity may be estimated as follows: In rooms fifteen feet wide one man to the yard in length; in those between fifteen and twenty-five feet wide, two men; in those more than twenty-five feet wide, three men to the linear yard.

Good ventilation consists in not permitting the air to exceed the standard of allowable carbonic impurity (6-7 parts CO_2 in air 10,000). Perfect ventilation consists in supplying every man at all times not only with air which has not been recently breathed but which is not contaminated with the products of combustion nor with the emanations of human bodies, which is not of uncomfortable temperature, and which is free from currents or draughts. The renewal of air so as to attain even good ventilation is one of the most difficult problems to solve, both theoretically and practically. It requires three thousand cubic feet of fresh air per man per hour; that is, if six hundred feet of air space is the allowance. It should be filled five times an hour, which would compel a change of the entire volume every twelve minutes. With a smaller allowance of space, the change must proportionably be more rapid. This change is necessary because, through the diffusion of gases, the air contaminated by the lungs, the skin, the generation of artificial illumination, and the decomposition of fuel mixes freely with the whole volume of air and defiles it. If it were possible for a man to inspire from a reservoir of fresh air and to expire into an independent receptacle, the allowance of six hundred cubic feet would not require prompt renewal. It is, however, useless with the means at our disposal to attempt perfect ventilation for soldiers' barracks: all that we can hope to attain is the technically "good." This is accomplished by means of the diffusion of gases and by the passage of air from and into the outer atmosphere. By the property of diffusion, by which every gas will enter the space occupied by another gas and the mixture will not separate, the gaseous products of respiration and combustion pollute the natural air but at the same time are themselves diluted, so that they do not present a concentration of harmful gases, but rather tend to their natural dissipation. To conduct the contaminated air out of the building and fresh air into it is the mechanical side of the problem. The gaseous diffusion goes on naturally, except as far as restrained by material obstacles. The systematic renewal of the domestic atmosphere is the real difficulty. The ventilation of elaborate permanent barracks is the work of specialists, and it is useless to occupy space here in the discussion of such problems. But in the temporary and the simpler permanent structures that shelter the troops provision to this end is necessary, is frequently overlooked, and should be carefully insisted upon. In one-story buildings the usual method is to carry air shafts from the ceiling several feet beyond the roof ridges, terminating them in cupolas with louvred sides. These should not be greater in cross-section than one square foot and they should be provided at the rate of one for every twelve occupants. If larger shafts, which are objectionable, are used, they should be divided by one or more longitudinal diaphragms. The outgoing current, usually sufficient in intensity, is created by the difference in temperature between the inside and the outside air in cold weather, or by aspiration due to the force of the wind then and at other seasons. This is practically natural ventilation, the supply being provided by the numerous doors and windows with attendant accidental crevices. Should the indraft be insufficient it may be increased by openings in the floor, which connect directly with the outer air and are controlled by registers. When the air supply is drawn from near the ground, care must be taken to keep that surface free from decomposing material or other filth; otherwise it is possible that active disease-causes may be introduced, and at the best the air-supply would be fouled. The outlet shafts should have valves to control the currents. In winter the fresh air is best warmed by introducing it through pipes at the base of the heating apparatus, which should be in great part enclosed by a jacket breast high. The outer ends of the pipes should curve down, to prevent the wind blowing in violently. The exit shafts should be placed in the corners of the room near the eaves and be tall enough to use the aspirating force of the wind without interference from the ridge. Valves may be arranged when, as sometimes happens, the cold air is liable to descend through these tubes. An excellent method to take advantage of those differences of temperature in the air upon which all natural ventilation depends, is to surround one

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tube by another a little larger and pass both from the ceiling through the ridge. The inner shaft should extend farther than the other, both above and below, and at the lower end should have a shelf extending nearly

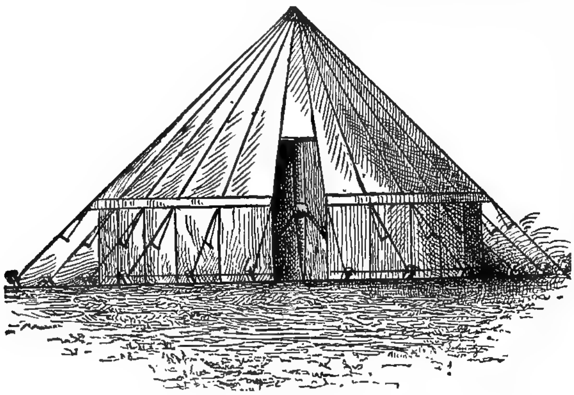

FIG. 3344.—Improved Conical Tent.

parallel with the ceiling for a short distance, to direct the in-coming air. (This shelf must be carefully wiped for dust at frequent intervals.) Ordinarily the warm air will escape by the inner tube and the fresh air will descend through the outer tube. Much air passes directly through ordinary walls, including those of brick and plaster. Walls that are painted or papered are much more nearly impermeable. The advantage of a hard finished or painted wall is that it may be washed down with a disinfectant solution when required. The disadvantage is that if there are many occupants the room must have ample openings for the admission of air.

The particular reason why the air should be constantly changed is because air just expired "is loaded with moisture, and is contaminated with organic matter which has a strong tendency to putrescence," and acts as a direct poison when taken into the system, as it must be if men are compelled to breathe it. And it is true also that numbers seem to intensify the ill effects, so "that the more men are placed together, the greater should be the air supply per head." It is difficult to impress upon line officers the evil, apart from the merely unpleasant, effects of overcrowding; for these manifest themselves slowly. But comparison between commands otherwise similar will always show the men least supplied with air to be the least effective and the most sickly. The results are the same as those in civil life in crowded domiciles. The walls and ceilings of plastered rooms should be lime-washed at least twice a year and the plaster should be renewed not less frequently than once in ten years, and oftener should there have been an epidemic, for the organic matter already referred to is liable to become entangled therein. Painted or hard-finished walls should be washed down with a bichloride-of-mercury solution semi-annually and the paint be renewed once in two years. The squad-room windows should be freely opened for at least an hour at reveille and again toward evening, regardless of any but the most stormy weather. In a suitable climate some windows should be constantly open. This seems to be too obviously necessary to re-

FIG. 3346.—Wall Tent.

quire formal instruction, but experience shows that without constant oversight even the simplest sanitary rules will be disregarded. The floors should be dry scrubbed or mopped carefully with a damp cloth, but unless restrained soldiers will invariably dash upon it bucketfuls of water requiring hours to dry. Wainscoted walls are frequent harbors of vermin and should be discouraged. Under the ground floors of temporary buildings there is a constant liability to the collection of slops, dust, and general débris, leading to the formation of what is practically a shallow cesspool. The care of his arms and accoutrements can be taught the average soldier much more readily than the intelligent care of his quarters. Soldiers in permanent barracks are supplied with single bedsteads and wire mattresses, and have cotton mattresses with sheets, pillows, and pillow cases. It is

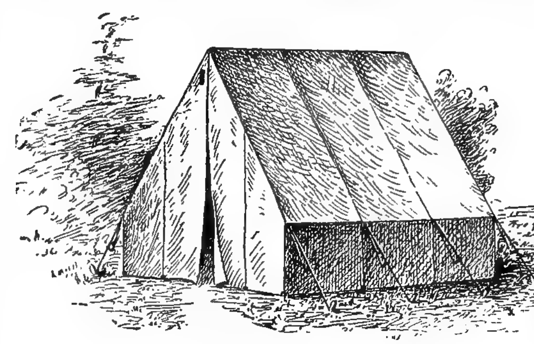

FIG. 3345.—Common Tent.

my impression that a good bedsack, with a reasonably frequent change of hay or straw, is more comfortable and more healthful than the cotton mattress after it has been used a few months. All bedding of whatever kind should be freely exposed to the sun half a day at least once a week, and the more frequently the better. Blankets should be aired and sunned every fine day, and neither dampness nor overheating should be tolerated within the quarters.

Tents and Camps.—In the field the improved conical (or modified Sibley), the common (or wall-**A**), or the shelter tent (*tente d'abri*) are used for soldiers and the wall tent for officers. In very active operations officers may use tents like those of their men. Hereafter, according to recent instructions, all tents will be tan color instead of white. The conical and wall tents are used for camps of some permanence, or for slow movements in heavy marching order; the shelter tent is used on campaign. As now issued, the conical tent (Fig. 3344) is 16 feet 5 inches in diameter at the base; it has a wall of 3 feet, from which it slopes inward to a circle 18 inches in diameter 10 feet from the ground. Its top is crowned and protected by a conical hood open at the side and the apex. It may contain a central stove; it is fairly ventilated; and it is the most economical and comfortable tent for a fixed, or fairly permanent, camp, or for a slow march. Its floor space is about 212 feet, and its cubic capacity is about 1,450 feet. Its official complement of men, which at the least is double the proper number, is 20 infantry, or 17 cavalry with their saddles. The com-

mon tent (Fig. 3345), has a wall of 2 feet, with a base of 8 feet 4 inches by 6 feet 10 inches. The ridge is 6 feet 10 inches from the ground. It has a ventilator 3 by 6 inches, protected by a flap, in both the front and rear wall. Its floor space is 57 feet, its cubic capacity is about 250 feet, and its regulation allowance of men is 4 mounted or 6 foot soldiers. In its greatest dimensions this would give each infantryman a floor space 16 inches wide on which to sleep. Were tents air-tight their occupants, at the military rate, would meet with speedy death; but the redeeming feature of dry canvas is its permeability by air, to which it offers slight resistance. Nevertheless it is manifest that, after making the most liberal allowance for probable absentees, men cannot remain in health in such close quarters. When the tent walls are wet, the swollen and saturated fibres confine the organic particles as well as interfere with the interchange of gases, and a closed wet tent speedily becomes offensive and poisonous to its occupants, notwithstanding the presence of the ventilators.

Officers in fixed camps use a wall tent that is 9 feet square at the base, with a perpendicular wall of 3 feet 9 inches, and a roof slanting inward to a ridge at the height of 8 feet 6 inches (Fig. 3346). It has a ventilator, 4 by 8 inches, in both the front and rear walls. This tent is covered by a fly, which is a false roof of canvas resting on the ridge, but at the eaves separated from the true roof by a few inches. It projects a few inches beyond the eaves. The fly is particularly useful in protecting the tent proper from rain and from the heat of the sun, by the air space between it and the roof. This tent has a floor space of 81 feet and a cubic capacity of nearly 500 feet. Ordinarily it is occupied by one or two officers, according to rank, and when not crowded is very comfortable in temperate weather. When tactical considerations permit, the door of the tent should open to the east.

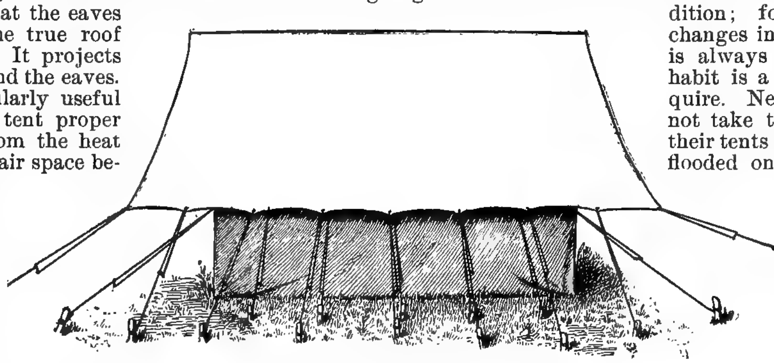
FIG. 3347.—Munson's Hospital Tent.

Hospital tents are larger wall tents with corresponding flies, used for the shelter of the sick. They are 14 by 15 at the base and 12 feet to the ridge, and may be opened at each end so as to be thrown together in extension.

All tents when the canvas is swollen by moisture, or they are directly exposed to the sun, are oppressive from imperfect ventilation and the heat. To overcome some of these objections Capt. Edward L. Munson, Medical Department United States Army, has devised a hospital tent which differs from the regulation tent in these particulars: (1) The fly is two feet longer and four feet wider. (2) There is a ridge pole for the fly one foot higher than the ridge of the tent. (3) The canvas at the apex of the tent is cut out over its entire length for a space one foot wide on each side of the ridge, except for one foot at each end, and its place taken by a rope netting with a mesh two inches square. (4) A canvas flap the full length of the tent attached to the base of the netting at one side, wide enough to cover completely the netting if desired for inclement weather and to tie down. (5) The ordinary tent ridge pole is dispensed with and the tent, except at the extremities, is suspended from the fly ridge pole. (6) The upright poles are prolonged one foot by metal rods which support the ridge pole of the fly. (7) The fly is white and the tent tan-colored. These tents may be pitched so that by a locking arrangement the flies may join to form a continuous ward. The advantages are a nearly complete protection of the tent itself from the direct rays of the sun; a large space above the tent whose air may be easily changed by the action of the wind with complete ridge ventilation through forty-eight square feet, as against much less than a foot near the apex in the regulation tent; and also a space between the ends of adjacent tents, which is valuable in contagious diseases and as affording storage room for ward property and giving more direct lateral entrance. Experimentally it has been shown that the temperature within the improved tent in hot weather, when the thermometer ranged from 87° to 104.5° F. in the sun and from 79.5° to 93° F. in the shade, averaged seven degrees less than that in the regulation hospital tent, and as compared with the conical wall tent it was from 9.5° to 18.5° F. lower. Apart from this difference of temperature, the ventilation is so much better that the natural quality of the air is fairly maintained. The objections, which are mechanical and not serious, are: (1) The metal prolongations of the poles are liable to fracture or distortion; (2) the ridge pole is in two parts, and under rough usage in transportation the malleable iron bands which maintain the union may be broken or bent so as to become unserviceable; (3) under very high winds, there is greater risk of the fly being blown away (see Fig. 3347).

No tent is properly pitched until it is well ditched. This should never be omitted, even when it is intended to move camp the next day, except in those peculiar regions where the rainless season is an established condition; for there are often changes in orders, the weather is always uncertain, and the habit is a valuable one to acquire. Nevertheless, men will not take the trouble to ditch their tents until they have been flooded once or twice, unless compelled by authority. This is to be insisted upon. The ditch should be about six inches wide and four inches deep, and should follow the natural slope of the ground into an adequate company ditch. As a rule, the ground is sufficiently damp to be unwholesome for sleeping directly upon, and the men are to be taught to protect themselves by straw, hay, boards, or some waterproof material, but not with green foliage or other damp objects, except in the absence of anything better to raise them from the mud. Authority must supply the place of experience in enforcing this with recruits in ordinary camps. A poncho or india-rubber blanket may be issued in the field. This waterproof may completely protect the sleeper from soil dampness, and is, perhaps, the most important single article for the soldier's use. Should the camp stand longer than a day or two, slight platforms should be raised a few inches from the ground for the men to sleep on. This is imperative in nearly every climate. Soldiers in the field very promptly learn to utilize material in that direction. The tent walls should be raised several hours every fair day, all the bedding and the covering of the floor should be withdrawn and exposed to the sun, and every particle of refuse carefully removed, and, if possible, burned. In warm weather one side of the wall to (leeward) may be raised at night. Every tent should have an adjacent unoccupied space of at least its own area, or, better, twice as great, in addition to the company street; and once a week the tent should be changed to the new site, and the old one scraped and exposed to the sun. When camps have some permanence and lumber is available, they often are floored with boards by the quartermaster. In such cases the floor should not be an immovable one. Every board should be loose, that it may be taken up for inspection. Ordinarily such floors do not appear as well, and there will be the temptation to conceal things beneath

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them. But vigilant inspection will remedy that evil, while with the fixed floor certain waste matter will work itself through, and it cannot be reached for removal. With care a camping-ground may long be kept whole-

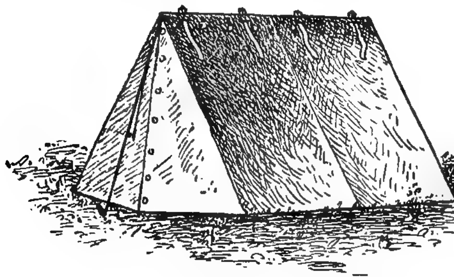

FIG. 3348.—Shelter Tent.

some. But tents, as just described, are now used only for small camps and under exceptional circumstances. An army of any size, and especially an active command, carries the shelter tent as personal equipment. This we have adopted from the French, who, for some cause, have discarded it. It consists of pieces of canvas, each about sixty-five by sixty-one inches, with a triangular flap at one end. The halves are buttoned together over light poles which are part of the equipment, so that when pitched the tent stands nearly four feet high at the ridge and the main triangle is five feet five inches long. The flaps close one end with an outward angle, increasing the length by twelve or fourteen inches (Fig. 3348). Four straps are let into one border which serve to make the blanket roll more compact, when the shelter-half is used as the wrapper (Fig. 3349). Each soldier carries one piece, or a shelter-half, so that two men have a complete tent between them. When dry, each man's part weighs about two pounds and a half.

When the camp is likely to remain for some time, log foundations or walls from six inches to five feet high and chinked with mud, are often made, and the tents are used merely as roofs. Under such circumstances shifting is impossible, and the internal police must be the more carefully insisted upon. As a rule, no excavations should be made for tents or huts, but there are exceptionally dry soils where, for the sake of warmth, this may be allowed after the general conditions are studied. But soldiers will frequently begin to dig without asking permission, and the medical and other officers should settle the question in advance. The plan of a camp is a matter of regulation not necessary to rehearse here, but every modification should be in the direction of expansion. The compression of camps is a military vice into which commanders are prone to fall, apparently under the impression that the less space occupied the greater will be the economy of labor, and the better will the troops be in hand. Pains should be taken to point out to both officers and men the evils of overcrowding, and the necessity for fresh soil, especially as to ventilation and the presence of débris. These increase directly with the size of the command. Fortunately, where shelter tents are used with only two men to a tent, the ventilation at least is not likely to suffer. But the camp, other conditions permitting, should cover as much ground as can be properly policed.

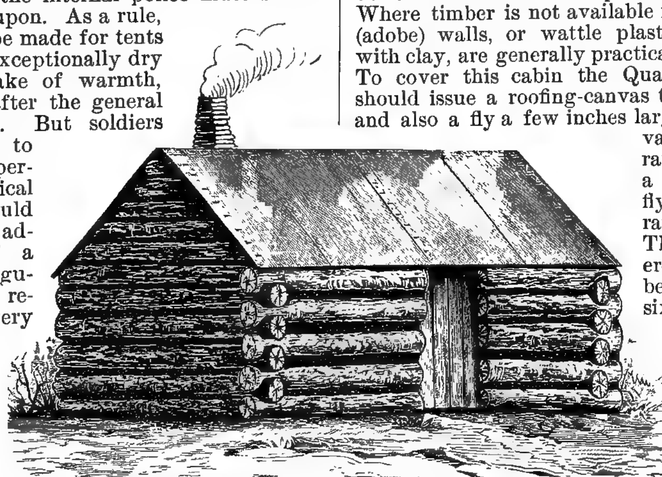

FIG. 3350.—Army of the Potomac Log Hut.

The foregoing applies chiefly to summer campaigns or those with little rest. For more permanent or winter camps the troops should be hutted and, as it is out of the question for the Government to build quarters in the field for a large army, they must provide the shelter by their own labor. The following scheme is a modification, so far as the huts themselves are concerned, of that suggested by Col. Charles Smart, Medical Department United States Army, which in turn was based upon the actual experience of the Army of the Potomac in Virginia. That army built huts nine feet eight inches by six feet in the clear, and covered them with shelter tents, to house four men (Fig. 3350). At one end was a platform for three to sleep upon. The fourth man was generally absent through some incident of service, but if present slept on the floor. Colonel Smart's plan (Fig. 3351) was for a cabin thirteen by seven feet, with a double bedstead on each side of the central passage. The hutting arrangement here proposed enables the coupled cabins to correspond with and to be sufficient for a squad of eight, which is the fighting unit of an infantry company. Where timber is available, pairs of log cabins should be built, each cabin to be eight feet by eleven interior measurement, standing end to end six feet apart, and the interspaces roofed. The doors should be in the adjacent ends but not midway, and the chimney outside of the house, built of stone or of sticks and lined with clay, should be in the middle of one long side. The walls should be six feet to the eaves and the ridge nearly ten feet from the ground. In each cabin two sleeping-platforms along one end and the longer side, each six and a half by four and a half feet and fifteen or eighteen inches from the floor, would accommodate two men apiece lying with their heads adjacent (Fig. 3352). These should not be closed in underneath, and under no pretence should double-tier bunks be permitted. Where timber is not available mud (adobe) walls, or wattle plastered with clay, are generally practicable.

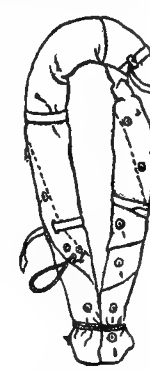

FIG. 3349.—One-half of Shelter Tent Rolled.

To cover this cabin the Quartermaster's Department should issue a roofing-canvas thirteen by fourteen feet, and also a fly a few inches larger each way. This canvas roof should be so arranged as to be detached at a moment's notice, and the fly be tied by fly-ropes to a rail just beyond the eaves. The covered, and by preference the floored, porch between the huts would be six by nine feet in the clear and its canvas roof should be seven by fourteen feet. There is no existing provision for the issue of such canvas, but neither should there be any difficulty in obtaining an article of equipment at once so useful and economical when its desirability is once impressed upon the authorities. It would not be costly and could be readily transported in the room of more formal tentage. If this is not provided, the roof must be of boards or "shakes," supplemented by spare shelter tents. Such a cabin would have a cubic capacity of seven hundred feet. This is insufficient theoretically, but it is the maximum practicable. The

constant fire would insure a free renewal of air even although the fresh volume might not be great at any particular time. If required, air holes could easily be provided in the chinking. As Colonel Smart points out, adequate space between the houses must be preserved. The minimum allowance between those of the same row should be equal to the height of the walls, and the passage in the rear between adjacent rows should equal the height of the ridge. Should this spacing encroach too much on the company streets, which should always be ample, the camp should be formed in "column of division." For both sanitary and military reasons, the space or porch between the twin cabins should be kept open front and rear. Before building, the ground should be freed from moisture and the whole, hut-sites and streets, be systematically ditched. The floors should be covered with sand and gravel well pounded and, when possible, concreted. The company streets, constantly occupied, for roll-calls and other duties, should be so prepared that the men may remain dry-shod. The cabin roof should be systematically removed to admit the sun, and when the sites are damp the floors should be covered with split logs. Banking or excavation is always objectionable, and except for ditching the surface of the soil should be disturbed as little as possible, for it is always to be remembered that the warmth of the cabin is liable to draw into it with the soil air the contained gaseous contaminations.

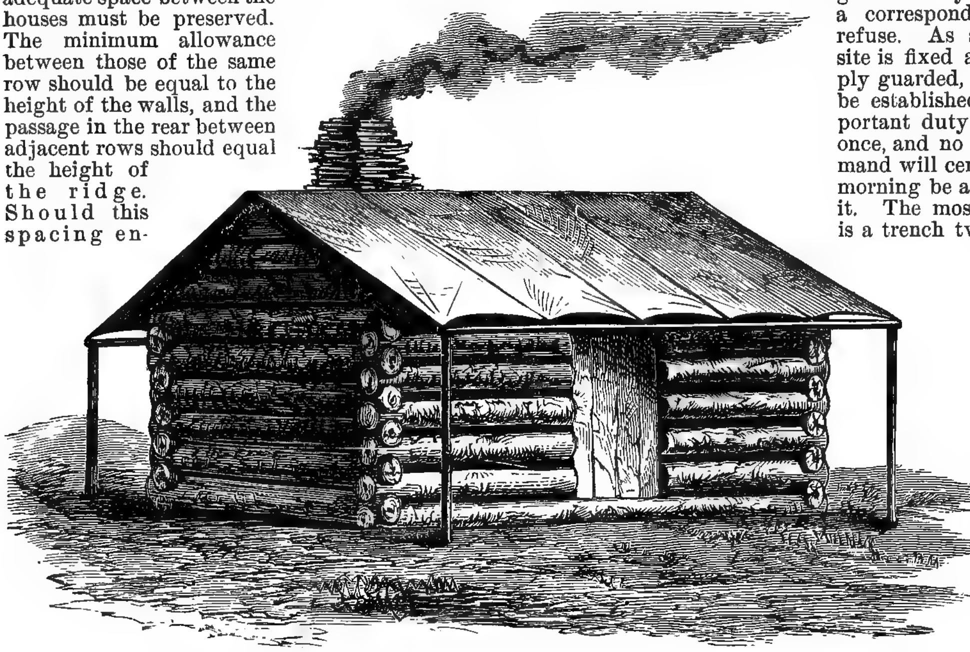

FIG. 3351.—Winter Hut. (Colonel Smart.)

Unfortunately the presence of a large army compels great density of population and a corresponding collection of refuse. As soon as the camp site is fixed and the water-supply guarded, the latrines should be established. This most important duty should be done at once, and no plea that the command will certainly move in the morning be allowed to postpone it. The most useful field sink is a trench two feet wide at the top, and from two to ten feet deep, in proportion to the probable stay. It is better to multiply the sinks than to have excessively long ones, twelve or fifteen feet being a suitable length. The earth should be thrown to the rear, and a layer of a few inches from it be covered in every morning and evening, and more frequently if the sink is much used. A shallow trench should be completely covered in one foot from the surface, a deep one at three or four feet. Sinks should be screened by bushes, and in temporary camps the seat is a pole supported by forks. In more permanent camps the trench should have box-seats open to the rear, and have some protection from the sun. The commission of any nuisance about the camp is to be rigorously forbidden; nothing is so demoralizing or so distinctly marks ill-disciplined troops as soil pollution of that kind. Urinals nearer at hand may be set apart, and their use be compelled. Special punishment should be awarded men who in such ways defile the vicinity of the tents.

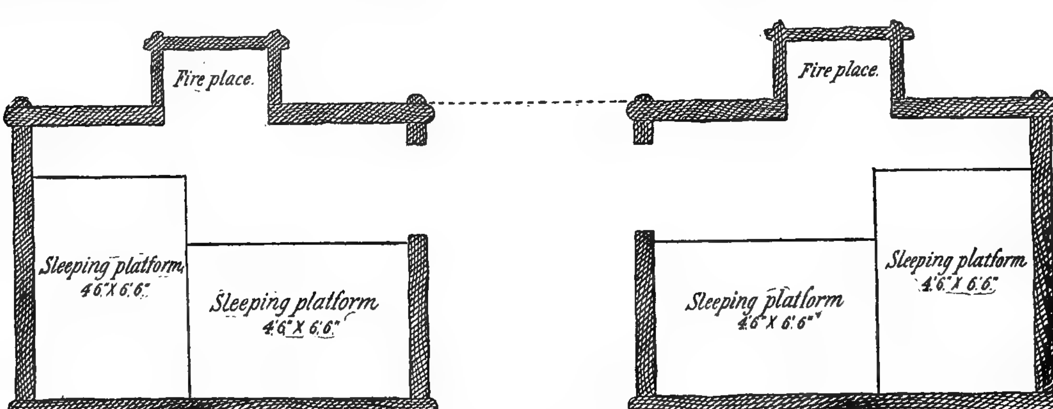

FIG. 3352.—Plan of Cabins for Squads of Eight.

The possible, and in dirty camps the probable, spread of disease by flies is properly receiving greater recognition than formerly when the modes of transmission were

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not well made out. Filthiness thus becomes an offence against health, as well as against decency and manners. But the practical maintenance of cleanliness in such places is much more difficult in the field than it might appear to be in the study. For instance, rocky soil, or that with a high ground water, compels the multiplication of shallow sinks with a corresponding risk of surface infection. Probably the most efficient method to keep a field sink clear of flies is to burn in it twice a day a little straw or paper well sprinkled with petroleum. Or the petroleum itself may be poured over the surface in small quantities and fired. Quicklime thrown into sinks is a cheap and valuable disinfectant. But in some regions it cannot be obtained at all, and with a large army its supply and particularly its proper distribution is impossible. The Quartermaster's Department now supplies for camps of position an apparatus whose expense for cost and manipulation is more than compensated by the increased comfort and health of the men. It is not impossible that this appliance might be a part of the train of every army, although the more mobile the force the less available would it be. It may be described in brief thus: The receptacle is a trough of galvanized iron, with the angles rounded for efficient cleaning. This is fourteen feet long, twenty-two inches wide at the top, eighteen inches deep at the lowest part, and is held in a wooden frame that supports it in position and protects it in transportation. This frame sustains seven seats. An independent urinal discharges into the trough. The trough is charged with a disinfecting mixture of quicklime and water, and the contents are pumped at stated intervals into an odorless excavating tank on wheels which is emptied in such place as may be designated. There have also been issued to some commands in the East portable conveniences on the earth-closet principle, whose contents are removed twice daily.

At the same time that the camp is determined the kitchens are to be established, and always in the relative place they would occupy were the camp to persist a month. Liquid slops from the kitchen may go into a pit, but other kitchen refuse should be thrown into barrels, not upon the ground. The best form of kitchen sink, when opportunity permits, is a deep excavation covered sufficiently to exclude the atmospheric heat, with a small trap-door opened only when slops are poured in. The relative coolness delays putrescence and flies avoid the darkness. All the ordinary refuse of the camp should be burned, if possible, unless there are military reasons, when in the presence of the enemy, to the contrary. Under any circumstances it must be carefully removed by transportation or burial. If transported, it must be to such a point as will not be offensive to any other camp. Only the most pressing exigency, in peace or war, should authorize the occupation of an old camp-ground. This rule is general and imperative. As soon as the men are encamped and have rested, the second day usually, the company streets and other open spaces are to be carefully marked out from encroachment.

Avoidable Camp Diseases.—This is not the place in which to discuss the treatment of the diseases to which soldiers are especially liable, nor even to enumerate those to which, like other men, they are subject; but attention is invited to the avoidance of several of the more important.

Enteric Fever is very apt to prevail among newly raised troops, and all fæcal discharges in camp should be carefully disposed of, because the incipient diarrhœa of a typhoid fever case cannot be distinguished from one that is not infectious. It is also liable to be spread by the urine. The pollution of drinking-water by the specific discharges is the most common method of distributing typhoid fever in civil life and in garrison; but in large camps it is probable that contaminated dust and infection-carrying insects are more important agents in its spread. It has been demonstrated that in the field, particularly, flies may carry upon their extremities and deposit upon food substances experimentally added to fæcal discharges, and it is therefore extremely probable that the specific agent is disseminated in the same way. Besides guarding the water-supply, prompt disinfection of the discharges of those known to be sick and of their utensils, the seclusion, boiling, and cleansing of soiled clothing, unremitting attention to the sinks, the protection of food supplies from flies and other insects, and the diminution of flies by general cleanliness are, as far as we now know, the general principles to be enforced. All cases of diarrhœa or continued fevers, however light, in recruits and especially among newly raised volunteers, are to be carefully scrutinized for fear of this disease to which they are especially liable, and such troops require particular and continued medical inspection until they become seasoned. All the excreta of the apparently sound, as well as of the sick, should be immediately covered with fresh earth if not promptly disinfected.

Cholera, like typhoid fever, has its essential seat in the intestinal tract, and is propagated by the ingestion of its specific cause derived from the discharges of a previous case. It is chiefly but not exclusively spread through polluted water-supply, and the continuance of an outbreak is best prevented by burning such soiled material as is not boiled, quarantining the infected men and the suspects, and moving the uncontaminated troops to a clean camp. Cholera is one of the few diseases that may be left behind by marching away from polluted sites. The excreta are best made harmless by acid disinfectants.

Malarial Fevers.—Although the original source of the plasmodium of malaria has not been determined, nor has it yet been isolated outside of animal life, it is established that the parasite is communicated to man by the sting of the *Anopheles quadrimaculatus* and perhaps by other varieties of the same genus of the mosquito infected from a previous case. Persons exposed to all the ordinary conditions for malarial poisoning, except the stings of these insects, have escaped the disease, and others free from all sources of infection except a contaminated mosquito have acquired it. Whatever other source of infection there may be is not yet determined. Obviously the prevention of such attacks is by the careful use of netting in garrison and permanent camps, and by supplying troops in malarious regions with pungent oils for anointing exposed parts of the person. The larvæ from which these disease-carriers develop are best destroyed by spreading petroleum upon their breeding-places. In other words, military hygiene does not materially differ from civil hygiene in dealing with this problem; but soldiers debilitated by previous hardship react much less readily and permanently than previously sound men.

Yellow Fever.—It has very recently been demonstrated by the army commission of which Major Walter Reed was the head, following the hypothesis that yellow fever is propagated by the mosquito, advanced in 1881 by Dr. Charles J. Finlay, of Havana, that in fact the female of the *Stegomyia fasciata* is an intermediate host for the specific agent of this disease. It has thus been removed from the class of filth diseases to that of the mosquito-borne, and its prevention consists simply in destroying the mosquitoes that are or may become infected. That is, those in the adjacent houses as well as those in the infected house should be destroyed. Gorgas has proved that by the destruction of all the actually or possibly contaminated insects the disease may be abolished, even in such a hotbed as Havana. This is best done by burning pyrethrum powder, one pound to one thousand cubic feet, or sulphur in the same proportion, or generating formaldehyde gas, each in a closed apartment, and the extermination of the insects in their breeding-places. As the infected apartment can be treated only after the patient leaves it, particular precautions in the way of netting must be taken, so that the infected insects shall not escape during the course of the illness. As far as can now be recognized, the clothing and quarters used or soiled by the sick do not spread the disease, and detention of persons coming from infected places need be enforced only against the non-immunes who have been exposed within the past five days. Usually there are localities not remote from the seat of an outbreak where yellow

fever will not spread, so that troops moved thither in times of epidemic, will be safe. These places, learned by experience, are generally higher and drier than the original site. Presumably, but this has not yet been demonstrated, the immunity depends upon the infecting insect having no *habitat* there.

Measles is sure to occur among newly raised rural troops. The contagion spreads so rapidly that large numbers will sicken simultaneously, and in the field the direct fatality is very great. This is so absolutely certain that special preparations should be made to meet it. The only escape from measles is by avoiding the contagious principle. In the civil war it temporarily unfitted for duty entire Confederate regiments and, in some instances, brigades. Among the national troops there were 67,700 cases with 4,200 deaths among the white, and 8,555 cases with 953 deaths among the colored, soldiers.

Mumps will also attack unprotected men and must be reckoned with in advance as liable to cause a widespread temporary disability, but its mortality is not worth considering.

Smallpox may so certainly be prevented that there is no excuse for it to occur in an army. But security is maintained only by intelligent as well as unremitting attention to the subject of vaccination by the medical officer.

Scarlet Fever is more liable to infect the residences of families in a cantonment or fort than the barracks, because from the latter the patient is promptly removed to hospital. Its direct contagion is not strong, but it is intensely persistent in connection with fabrics and buildings. There should be the most careful scraping, lime-washing, scrubbing with bichloride 1 to 1,000, and ventilation. Small, old houses thoroughly infected should be burned. Formaldehyde is efficient for exposed micro-organisms, and sulphur at the rate of three pounds to one thousand cubic feet may be used in carefully closed apartments.

Diphtheria, fostered by foul air when once introduced, is exceedingly infectious and clings persistently to places. Its disinfection should be as thorough as that for scarlet fever.

For other contagious diseases and especially for an account of disinfectants, their value, and their mode of action, attention is invited to the special articles thereupon.

Marching.—The regulation direct step is thirty inches from heel to heel at the rate of one hundred and twenty steps per minute in quick or marching time. In double time the step is thirty-six inches and the rate one hundred and eighty steps a minute. Were there no halts, the distance covered would be three and two-fifths miles in quick time, and at the double it would be one hundred and eighty yards a minute, or a little more than six miles an hour. In practice this is reduced by halts to a trifle more than three miles for marching time. The double is not properly a marching step. Large bodies of troops can use it only for short distances in emergencies, nor can any number of men use it long. Running is quickly exhausting, and it is useless to bring infantry into action out of breath. Nevertheless, short drills at the double are useful as a gymnastic exercise; but they should commence with very short distances, and after long practice should never exceed twenty minutes in duration. Men should be encouraged to fall out at will; for a heart may very easily be irreparably overstrained, and an exercise intended to strengthen the soldier may ruin him for life.

To conduct a march properly requires experience, or a closer attention to theory than is often given. Except the necessity is very pressing, the first march should be but a very few miles—barely enough to clear well the old camps should the conditions admit a halt, for at the outset there is friction everywhere. Each day's march may be gradually increased until, after a fortnight, the maximum is reached. If the troops have been accustomed to marching drills, the maximum can soon be attained. Every eight or ten days, besides Sundays, there should be an all-day halt for rest and repairs. When fairly seasoned, infantry will outmarch cavalry in a long journey or campaign. To the possible objection that marching is a matter of tactics wholly within the province of the line, I reply that, whoever may be charged with its execution, it is hygiene, whose neglect swells the list of the disabled. Rules as to the maximum distance are impossible. Marching is influenced by weather, by roads, by the immediate end in view, and by the spirit of the men. The ease with which troops march is inversely to the size of the command. A regiment will outmarch a division; a division will outmarch a corps. Over good roads fourteen miles in ten hours, one day with another, is good marching for a large army. But a regiment can make the same distance in four hours and a half, including halts. Infantry and mounted troops should not march together if it can be avoided. Infantry should march with as wide a front and in as open order as possible, for crowd-poisoning follows the collection of large bodies of dirty, heated men out of doors as well as in houses. Troops, after the first few regiments, always march in dust or mud, unless the roads are frozen; and very close order is particularly distressing. Frequent halts are necessary; for the best troops will lose distance, and the rear of the column is in a perpetual state of worry trying to close up. No particular command should be started until it is closed up in the rear and the rear ranks have had rest. After the first few miles the men should be encouraged to spread out and sit down at every halt, for no one can tell how long the delay may be; but they should never sit on the damp ground, or without proper protection from it. The French make use of a device during temporary halts which avoids loss of time in taking up the march, and is particularly efficacious in keeping the soldier from the mud. Squads of twenty or thirty form a circle, and each man sits on the knee of the man behind him. This saves disarrangement of packs, keeps the men well in hand, and affords considerable relief.

Unless the command is very small, the men should be required to march without regard to the minor obstacles of mud, water, and the like. The delay caused by the head of the column picking its way around a mud-puddle, or across a small stream to avoid wet feet, becomes very serious by multiplication as it is propagated to the rear. Hesitation in the leading files is magnified into serious halts at the tail of the column, and the jerky progress is trying to muscle and to temper. Commanding officers who lead the march do not always realize how the other end of the column suffers, and it sometimes happens that a mounted officer in command needs to be reminded that infantry are foot-troops. Each regiment in daily turn should lead within its next higher command, and the same rule should follow with brigades and divisions. It is a relief on alternate days for the companies and the regiments to march left in front. Music is a real aid on the march, and the trumpet cannot replace the fife and drum as an exhilarant. The mere tap of the drum in giving a common step assists. A full band is a positive stimulant, and the men should be encouraged to sing.

Raw troops almost always overload themselves. Every ounce carried tells, and at frequent inspections everything not distinctly necessary and authorized must be thrown away. The authorized articles should always include a change of underwear, preferably flannel, but no superfluities; this whatever may be the style of equipment used. Nor should the men, when tired, be allowed to discard necessaries which they are likely to need. Raw troops will often do this under temporary discomfort. But it is easier to announce such rules than to enforce them. In temperate climates marching men are apt to suffer from chafing in the groins and nates, and from sore feet. Both are very distressing when severe, and unseasoned troops will break down with just such temporary troubles if pressed too hard at first. The sufferers should be encouraged to report for relief at sick-call held after camp is made, and should be prescribed for but not be readily excused. Ingrowing

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nails, corns, and blisters on the feet require careful attention.

If a man is found in the ranks who "walks on the nail," the terminal phalanx of any of whose toes is flexed downward at right angles, and the toe begins to get sore, as it will by sand lodging under the nail and exciting inflammation, he should be taken out of the ranks at once. He may ride for the time in the wagons, but he is useless as a soldier, and should be discharged, as he never should have been enlisted. A blister on the foot is to be evacuated by running a thread through it and allowing the fluid to ooze. Sore feet should be well washed, dried, and then greased. To soap the feet is often a preventive, and the use of strong alum baths, when practicable, is commended. Salicylate of soda applied locally checks excessive perspiration. An efficient powder to prevent chafing by shoes or other clothing, or by the saddle, is three parts of salicylic acid to ten of starch and eighty-seven of powdered soapstone, each by weight. While general cleanliness is important, that of the feet is necessary. Too much attention can hardly be paid the locomotor apparatus. It is that which carries the intelligent, working, fighting part of the man, and when it is not efficient the soldier might as well be at home. Battles and campaigns have been won by legs, and will be again. The army that marches best, with any approach to equality in other respects, is the successful army.

The men should be instructed to bathe thoroughly the anus and genitals daily, to avoid chafing and balanitis. Many experienced soldiers, while on the march, wash only the eyes and mouth on rising. This sounds uncleanly, but it has some advantages. A damp, not wet, towel may be used on the face and neck. But upon reaching camp the more carefully men bathe the better. The feet and the head are to be especially cared for, the hair always being kept short. Canteens should be filled with water, and better with boiled water, or with weak tea before starting, but none should be drunk, unless a rest is made for a meal, until the end of the march is known to be at hand. The man who begins to drink water on the march will always be thirsty, will drink repeatedly, will soon exhaust his supply, and will be uncomfortable all the time. Men should not be allowed to leave the ranks to replenish canteens except by order, nor at all unless the supply is known to be pure. The sensation of thirst can usually be avoided on the march by carrying a pebble, or some other small solid substance, in the mouth. Its presence stimulates the salivary glands, and these keep the fauces, the common seat of the sensation of thirst, moist. The system is easily educated to abstinence from fluid between meals, and the habit is one of great convenience to men a-field. The exception is in the tropics, where some latitude must be allowed; for excessive loss of body fluids through perspiration predisposes to heat prostration, and a part of the liquid must be replaced. But water-drinking on the march should always be limited in amount and be indulged in only at considerable intervals. Under ordinary circumstances the earlier camp is made the better, for the men have more time to make themselves comfortable for the night. Night marches are to be avoided, if possible. But in hot weather, in non-malarious regions, an occasional night march is a relief. As a rule, however, the loss of sleep and the general discomfort they cause outbalance any ordinary advantage, some great military requirements excepted. In a torrid climate, whenever possible the middle of the day should be avoided in moving troops; and the marches should be regulated so as to avoid having the sun shine directly on the men's backs, because of its depression to the spinal cord. Straggling, the loitering behind of the sick, the tired, the lazy, the ill-disciplined, is an evil that indirectly affects the health and the *morale*, and directly concerns the military vigor of the column. Its prevention, so far as those out of health are concerned, depends upon the prompt and rigid scrutiny by medical officers of all who fall out claiming to be sick, and their immediate disposition. Frequently a few hours' rest in an ambulance will bring a man up fresh at the end of the day, but that is an indulgence to be exercised with great discretion.* The really ill are to be carefully transported. With good troops such attention always is its own reward; for they will put forth every effort, believing they will be cared for when exhausted. When an army is about to leave its base, the men should be rigorously inspected for venereal disease, and cases of it should be segregated for treatment, to be sent forward as re-enforcements after recovery. The presence of venereal with moving troops is an element of weakness in every respect.

GUARD DUTY.—Guard duty, whether in garrison, in camp, or on picket, on account of the responsibility and vigilance it imposes and the loss of sleep that it compels, is the most exacting and wearing that befalls a soldier. Ordinarily, guards are relieved every twenty-four hours, during which period the soldier may remove neither his clothing nor his accoutrements; and he is on post and alert two hours, with an interval of four hours' rest, four times during the tour. It is the nights on guard, in all weather and with heavy responsibility, that break men down most rapidly, and that give a soldier his characteristic face.

A tour of guard should not occur for a seasoned soldier oftener than once in five days, nor for a recruit than once a week. The longer the interval the better for their health. The present Manual of Guard Duty (par. 27) requires the details for post guards to insure for privates, as far as practicable, not more than one tour in seven days; and, except in emergencies, privates will not be detailed for guard oftener than once in five days. Formerly the whole subject was left discretionary with the commanding officers and they would frequently insist upon so many posts that the men could not get more than two nights together, or three out of five, in bed, and I have known men to be on guard alternate nights in profound peace. Such an abuse of power is not likely to occur, but the commanding officer must always be the judge of the emergency, and usually advice and expostulation in such cases are wholly thrown away. Nevertheless attention should be respectfully but plainly invited to the matter when necessary. In very severe weather the reliefs should occur oftener than once in two hours. There are conditions when a "running guard" saves the men. In a running guard the whole period is so divided between the men that any particular soldier goes on but once during his tour, or once during the night, and is able to rest the remainder of the time. The guard must be larger than usual in order not to keep one man too long on post, but the compensation lies in the uninterrupted rest before and afterward. When there seem to be hygienic reasons for it, it should be recommended. If a light supper and a bowl of hot coffee be given a man just before going on post late at night, and in garrison this usually can be arranged, it is of decided advantage. The coffee requires warmth and bulk rather than strength. Guards in a distinctly malarious region should be given five grains of quinine in coffee (not in whiskey) at retreat, and should be required to wear flannel next the skin.

SETTING-UP.—A man who has received judicious physical training as a soldier can readily be distinguished from his companion who remains on the farm or in the shop. He has a springy step; an erect and easy carriage; his abdomen is retracted, his head is mobile but well raised, his chest is expanded, and his shoulders are square. Square shoulders are the natural distinction between soldiers who have been long in the ranks and those who are raw. The position of "attention" is constrained, but it is one in which the muscles are symmetrically occupied, and it is the basis of martial bearing, showing itself more conspicuously when the man is in motion. Volunteers are apt to undervalue the little signs and mannerisms that mark the regular, but there is

* Consult carefully this HANDBOOK, vol. i., p. 476, commencing "On the March."

no doubt that these are the indications of a system that is founded in reason and results in efficiency. The setting-up drill, therefore, should be sedulously cultivated as a gymnastic method of physical improvement; but care should always be observed not to carry the exercise of swinging the extended arms in circles to excess. This seems simple, but is very fatiguing, especially when the heart is irritable, and leads to faintness in recruits.

There is a vicious habit in the British army, not common in our own but mentioned here as a warning, where the drill-sergeant seeks, not only to expand the chest, but to keep it expanded. The recruit is required to stand bolt upright, with the head well back and the chest inflated by the fullest inspiration. This artificial dilatation is sought to be maintained without giving place to a corresponding expiration. The expiration being held in abeyance obstructs the circulation and impedes the cardiac action. With the imperfect respiration the aëration of the blood is likewise imperfect, the abdominal muscles are weakened by overstrain, and their action is impeded by the forced depression of the diaphragm, while the increased measurement of the recruit's chest is secured only at the expense of its mobility, and at the risk of vesicular emphysema. In this distended chest the heart is displaced downward, the area of the impulse is increased, the beat becomes jerky and too powerful, and in frequency it may reach 110, with irregular force and time. This is persevered in from day to day, training men into picturesque soldiers, but soldiers whose vital organs are weakened by the strain. For the foregoing analysis credit is due Major F. Arthur Davy, a medical officer of the British service. Our officers should be watchful to prevent its introduction here.

GYMNASTICS.—Everything leading to increased physical vigor, and mental alertness on the part of men and officers is to be encouraged. In peace, the ordinary garrisons are so small, and the work required of them is so various, that there is little lack of physical exercise in the sense of mere muscular exertion. In war, or in the field, there is neither apparatus nor time to develop the skilled gymnast. But, when circumstances allow, the systematic training in feats of agility and endurance amply repays the trouble taken. In large garrisons with proper buildings this can be done in all weathers, with confidence that the chest capacity and the muscle measurement will surely increase. The modern target

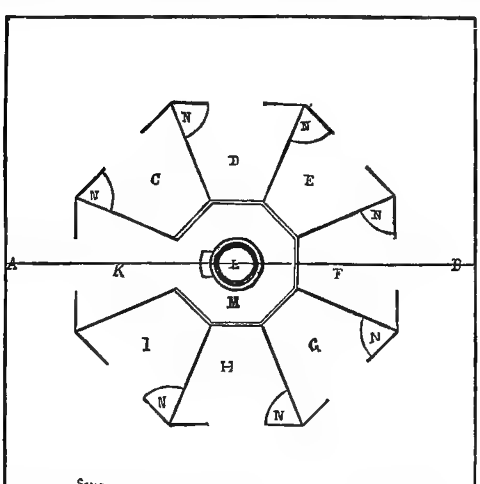

FIG. 3353.—Bathing Cells.

practice is a particularly valuable form for the co-ordination of the eye and hand, where each experiment checks on the spot its immediate result. To this add bayonet and sabre exercise; scaling drill, such as the firemen of large cities practise; field trials, as "hare and hounds"; the various equestrian exploits for cavalry; and, the locality permitting, swimming drill as well as swimming for amusement. A carefully prepared scheme of formal gymnastics as preparatory exercises for recruits should be developed later into the practical studies hinted above, midway between pastime and instruction. Much more attention is now paid to gymnastics than formerly, but they do not yet appear to have the practical recognition they deserve.

BATHING.—Cleanliness of the soldier's person as well as of his habitation demands a vigilance by the officer not always exercised. For, besides providing him with

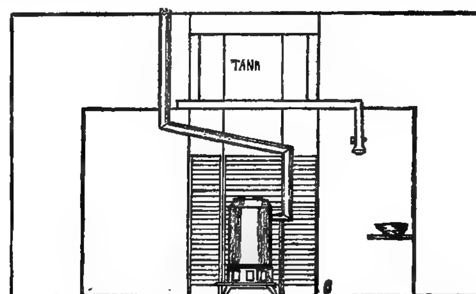

FIG. 3354.—Bathing Cells; Vertical Section.

food, clothing, and shelter, and regulating his daily occupation, the military authorities must exercise a paternal supervision over the man himself. It is not sufficient to see that the arms are bright, the uniform spotless, and the bedding neatly rolled. Dirt that is hurtful is not the mud of the highway or field, or the dust of the parade caught on the shoes or on the outside of the clothing; it is the cutaneous débris, mingled with dust and dissolved in perspiration, soaked into the underclothing; organic dirt that offends the nose as well as the eye, that depresses the subject and may poison his comrade. The oppressive odor of personal filth peculiar to human crowds can be avoided among soldiers in barracks only by inspections that expose the shirt, the stockings, and the skin under them. Men's necks, breasts, feet, and legs should be frequently and critically inspected, their hair must be kept short, and their whole persons be washed as often as necessary. That opportunity for ablution may be had with the most scanty water-supply, and the most limited appropriation, these cuts (Figs. 3353 and 3354) illustrate. By such an arrangement of warm shower-baths seven men can wash their entire persons simultaneously and in privacy with a minimum of waste. (Fig. 3353 shows the plan, and Fig. 3354 a vertical section on the line *A*, *B*. *K*, opening to stove; *L*, stove in central apartment, *M*, to heat the room and water in the tank; *N*, shelves in corner of bathing cells *C*, *D*, *E*, *F*, *G*, *H*, *I*. *M* is 5 feet in diameter, and the bathing-cells are 4½ feet deep and 5 feet 3 inches across the widest end. About the central apartment should be eight posts to support the tank, and between these slat-work, to allow the warmth from the stove to enter the bathing cells. Doorways to be 2 feet wide and 6 feet 6 inches high; cells to be 8 feet high in the clear, and the jets to be 5 feet 6 inches from the floor; the cell floors to slope downward and inward one inch to a common point, and a drain pipe should carry off the waste water. Very little water is used by this method, and the stove heats both the tank and the little rooms. Such baths are used at Rouen, and this plan was proposed to the army by Dr. Billings in 1875, but does not appear to have been acted upon. Dirt fosters discontent and diminishes efficiency.

As a military exercise, apart from its hygienic advantages, all soldiers should be taught swimming. In swimming, men should be cautioned against swimming under water, on account of danger to the hearing. If men *swim*, not merely paddle in the water, and bathe, there is no harm going in the water while perspiring moderately.

Colds are caught by attempting to cool off before plunging in.

General Considerations.—Military hygiene must take account of the new environment of the recruits, and of the occupation, as well as of the clothing, food, and shelter of soldiers. In peace the United States army is recruited chiefly from the ranks of unskilled labor, with a fair sprinkling of clerks and mechanics. The enlistment is for three years, and, contrary to the popular belief, the most of the men are native-born. As a rule, these soldiers are men of brawn, not of brain, who enlist at first from no special love of the profession, but merely to secure a present support. Those who develop an aptitude for arms enlist again. For war, volunteers of all classes come forward, from patriotism or love of adventure. The regular troops are picked men, physically; the volunteers are apt to be not so well selected in that respect. Over both classes officers must exercise constant and real supervision and control. The intelligent selection of men to be soldiers is indispensable for an effective army. It is perfectly useless to attempt making a fighting force from immature or imperfect men. Military hygiene can do nothing, in the creative sense, with men not physically sound at first.

This general rule should always be remembered: Troops from the rural districts break down more readily than those from cities. The agricultural recruit will be better nourished, and at first may appear the more vigorous. That is due to his previous life of moderate exercise in the open air, of stated and sufficient meals, and of uninterrupted nightly sleep. His mind and body work slowly, and generally best in accustomed grooves. To him the plainer and more scanty food, the garrison exercise which is less or the marches which are more fatiguing, the prompt obedience without discussion and the sharp movements without voluntary rest, the excitement of active service, the lack of comfortable surroundings when the day's work is over, and especially the exposure at night, marching or on guard, in all weathers, with broken and insufficient rest—all these are conditions that disturb and lower his physical estate until he becomes inured to them. On the other hand, the young man from the city has been accustomed to all grades of mental and physical excitement, he has probably eaten spare, irregular, and perhaps poorly cooked meals, and has lived in crowded and ill-ventilated rooms; he may have been insufficiently clothed; he certainly has been used to late and irregular hours, and to spasmodic physical exertion. Both mind and body are more active, and, although he may appear less stalwart, he represents the survivors in a struggle for existence that has not beset his comrade from the country. Discipline is distasteful, but its methods and its aims are more readily grasped. To him the military life is physical promotion, in that it substitutes regularity, system, and sufficiency for irregularity and inadequacy in meals, exercise, clothing, hours and amount of rest, and atmospheric purity. The new conditions disturb both classes, but to the city men infinitely less inconvenience follows. This is distinctly tested where city and country regiments lie side by side, or, as I have seen, where a city company has been incorporated in a country regiment. After elimination by length of service the country regiments rival those from the city in endurance, and generally excel them in familiarity with the implements and ways of outdoor life. An important factor in estimating the efficiency of newly raised troops is their comparative liability to certain contagious diseases. As a rule, urban residents have all the children's diseases in early life, but many country people escape them then. It follows, practically, that mumps and measles, serious diseases to treat in camp, have a favorable field, and upon the exposure of one individual are sure to invade, as epidemics, troops from the country, while those from the city escape lightly. Measles, with a high rate of mortality, kept large sections of both armies unserviceable during the earlier months of their enlistment in the civil war. New troops never escape such troubles, and all officers must be prepared for their occurrence, both as reducing the available strength and as magnifying the sick-list, and this may be foreshadowed as to degree by a knowledge of their civil residence.

As the consequence of efficient military hygiene, which involves moral as well as physical training, the average recruit at the completion of his enlistment is a better man in mind and body, if his company has any discipline worthy the name. He has learned obedience, responsibility, promptness, order, the value of co-operation, and attention to his own duty as moral qualities, and the importance of cleanliness, of regular habits, and of stated and sufficient bodily exercise as physical ones. The slouchy, dirty, careless, and perhaps insubordinate rough becomes the erect, neat, and disciplined man-at-arms, distinctly charged with the preservation of the peace. His body and mind are both in better tone. The bucolic youth has his wits sharpened and his limbs suppled, his mental and moral horizons are widened, and he becomes alert and self-reliant in mind, and more elastic in physique. To this development all officers must co-operate, and the process is distinctly the embodiment of military hygiene.

After the novelty of his new scenes has worn off, and his interest in attaining his military education has been dulled by acquisition, the soldier in garrison suffers from want of occupation. All officers serving with troops know, and many have proclaimed, that *ennui* is the bane of military life, and is at the bottom of half of the physical and nine-tenths of the moral evils that annoy both officers and men. An officer worthy of his commission has internal resources that will pleasantly occupy him, if he will but use them; but for the soldier employment must be found. Idleness, discontent, and sickness are a military trinity, interdependent. It is notorious that in the field a marching column is a healthy body, and that the sick-list increases in direct proportion to the age of the camp. The excitement of the march keeps the men well. In camp and garrison similar employment must be found. Marches into the surrounding country, temporary camps from garrisoned posts, occasional bivouacs, athletic games, the erection of field-works with practical illustration of their defence and attack—all are physical methods of improving the general and individual efficiency of the men; and dramatic and variety entertainments, reading-rooms, lectures by officers on practical subjects, and, above all, music, are valuable moral aids. I have little faith in so-called literary and debating societies for soldiers. Their tendency is to introduce the town-meeting element, which has no proper place in military life. Nor is it ever reasonable to expect the rank and file to be really interested or to excel in intellectual pursuits. It is especially in the enforced monotony of winter camps that systematic effort is required to amuse and to interest the men. The narrow quarters, the imperfect means for ablution, the inconvenient alternations of heat within and cold without their huts, the long dark evenings and late chilly dawns, the prolonged sexual abstinence, and the treadmill round of minor and annoying drudgery—all tend to disturb the nervous balance, and lead to attempted relief through cards, tobacco, alcohol when it can be had, excessive sleep, and sometimes vicious gratification of natural passion. The physical evil of cards is due to constrained positions long sustained in impure air, and the nervous mischief is the gambling excitement. Although a common vice, gambling should always be discouraged in the army as tending to foster a race of sharpers who fleece their comrades and beget bad feeling directly to the prejudice of discipline. It is very necessary to break up the weary tedium of winter camps by varied amusements officially encouraged, and useful hints may be taken from the systematic provision to that end that Arctic explorers make in anticipation of their inevitable and more serious blockades. Under all circumstances music, especially martial music, dispels melancholy and stimulates and enlivens all whom it reaches. The most unmusical of men feel its emotional influence and respond to its appeals. It is not economy, it is parsimony, to dispense with bands on ac-

count of their cost, whether in the field or in garrison. This is particularly true of unseasoned troops, but I believe it holds good for all. The suppression of music for military reasons at the siege of Yorktown, I am confident, injured the troops by the gloomy silence that resulted. On the other hand, the use Heintzelman made of martial music at the battle of Williamsburg shows its value as a moral stimulant.

No sketch of military hygiene, however meagre, should omit a tribute to the late Dr. E. A. Parkes, of the British service, whose copious experience and clearly expressed knowledge have done so much to improve the well-being of enlisted men the world over. Parkes' "Hygiene" is the general reservoir from which for many years the military student must draw his theoretical information.

The officer, whether medical or line, who would properly care for the troops must keep an ever-vigilant watch over their interests. But concern should not degenerate into friction and worry. Perpetual nagging, too curious supervision, is almost as bad as contemptuous neglect. He must love his duty, must love soldiers and a soldier's life, and, while commanding with impartiality, must under all circumstances lead and protect his men.

Alfred A. Woodhull.

MILIUM.—Grutum, Strophulus albus, Acne albida, Tubercula miliaria, Tubercula sebacea. It consists of small, round, or pointed bodies which contain sebaceous matter and epithelial cells, and are situated immediately beneath the epidermis. Their size varies from that of a pinhead to that of a small pea; they are white or yellowish in color, rather hard in consistence, especially so when calcified, in this instance being termed cutaneous calculi.

They are most commonly situated on those parts of the skin which are well supplied with sebaceous glands; therefore they will be found generally about and upon the eyelids, on the cheeks, and in the neighborhood of the lips. Another favorite locality for this affection is on the genital organs of both sexes: in the male, on the scrotum and penis; in the female, on the labia minora.

The affection seems to occur more frequently in women, at about middle life, being the cause of real suffering from the attendant disfigurement. In men I have seen it attack the genital organs more frequently than any other part of the body. The disease is far from uncommon, but it is so trivial in its nature that people seldom seek treatment for it, and our advice is sought only when the number of milia is large, or when they are large in size, or, finally, when they occasion distress on account of their prominent position on the face. Fortunately, these little tumors do not grow continuously unless injured; otherwise, after attaining a certain size they remain permanently quiescent.

These little tumors consist of accumulated sebaceous matter and of epithelial cells within a sebaceous gland and its obliterated duct. In the centre there is a core of sebum and, arranged concentrically about it, layer upon layer of epithelial cells. This symmetrical arrangement of the layers Kaposi happily compares to the structure of an onion. The milia are situated directly under the epidermis. Kaposi claims that they also have over them a very thin layer of corium.

Virchow and Rindfleisch believe that the seat of the disease is in different portions of the hair follicles, but the fact that these little tumors occur in localities totally devoid of hair or lanugo, as the glans penis, would not support this idea. No cause has ever been discovered for this disease; it would seem that there must be another cause for it besides the mere mechanical occlusion of the ducts, but thus far it has escaped us.

Diagnosis.—With the exercise of some care there is little chance of confounding milium with anything else. The disease most apt to be mistaken for it is comedo, but the following points ought to differentiate them: In milium the color is white or yellowish-white, it is covered by epidermis; it cannot be pressed out unless the epidermal layer is incised, and as a rule it is the sole lesion present, although cases do occur in which several affections coexist (as acne with milium, or comedo with milium, etc.).

Prognosis.—The disease is obstinate. It remains in the same condition for years, or the little tumors become calcified, forming the so-called cutaneous calculi.

Treatment.—This should be incision of the thin layer of epidermis over each individual little tumor and the extrusion of the mass as a whole by pressure. This little operation is almost bloodless and leaves no scar.

N. J. Ponce de Léon.

MILK.—There is no one article of food more important to the human race than milk. In health it is in universal use; in pathological conditions it serves as the basis of dietetic treatment; and in the feeding of infants, both by natural and by artificial means, it is the one essential source of nourishment. A knowledge of the physiological and chemical properties of milk is therefore of far-reaching importance to physicians, and deserves more attention and study than are generally accorded it.

It is the milk of cows which has been most extensively investigated, the knowledge of which must underlie our consideration of the subject in general.

Secretion of Milk.—In the mammary gland of mammals, nature has provided a mechanism of extreme delicacy for the elaboration of milk. It is a storehouse for its product in a limited degree only, its principal function being the secretion of milk, in accordance with demands made upon it by the nursing offspring, or, in case of the domesticated cow, by the artificial conditions which surround it. It draws its material from the various parts of the animal economy by means of the blood, recombining them and building them up into the constituents of milk—the fats, sugar, proteids, mineral matter, and water.

The specific secretory action of the mammary gland, as opposed to simple filtration and excretion, is shown by the chemical analysis of milk. We do not find, for instance, the milk-sugar or lactose, one of its principal constituents, in the blood. The lactalbumin also differs in certain respects from serum albumin; and the mineral matter is found in different proportions from those which exist in the blood. Filtration and excretion, therefore, are only parts of the general process, while the synthetic property of the mammary gland depends, probably, upon the activity of the epithelial cells lining the ducts of the gland. The gland is of the compound racemose variety, and thus presents a large surface for the exercise of its function.

The proportion of solids secreted in milk is not constant. It varies with the variety of mammal and with the variety of species, that is, according to the breed of the animal. It is also influenced in an individual animal by such factors as changes in the atmosphere, *i.e.*, the seasons, by changes in food, by the hygienic surroundings, by emotions, fatigue, sickness, and at different stages of the milking period, being more watery in the early periods, and more concentrated in the late periods. In nursing women the catamenia and pregnancy are also conditions which influence the composition of the milk.

The *quantity* of milk secreted, especially in human breasts, in the natural state, is adapted to the age and gastric capacity of the infant, but this function is modified greatly by artificial conditions.

That the mammary gland has also the function of excretion is shown in its power of eliminating certain drugs ingested by the mother. The most important of these are morphine, opium, atropine and belladonna, iodine, arsenic, bismuth, antimony, zinc, lead, mercury, and iron. It is interesting to note, however, that other substances, such as bile acids and bile pigments, are not excreted by the mammary gland.[16] Toxins, on the other hand, may be eliminated and secondarily react upon the nursing infant. The majority of drugs, however, are not excreted in the milk.

Certain classes of foods contain substances which may be excreted and modify the taste of milk, notably turnips, onions, garlic, mouldy hay and grain, etc. The

taste of milk may also be influenced by exposure of milk to volatile substances. This property of absorption of odors is very great. The odors of strong disinfectants, kerosene oil, and similar articles, if brought in close contact with milk, are readily taken up and impart their properties to the absorbing medium.

Origin of Fat in Milk.—Microscopically, the fat globules may be seen in the epithelial cells of the mammary gland. They are discharged into the milk ducts either by a breaking up of the cells themselves or by a contractile extension similar to that which occurs when the amœba ejects its food.[5] The question of how much fat is produced by the secretory mechanism of the milk glands, and of how much is obtained from other organs and tissues and eliminated from the blood by the milk glands, has not been determined. Winternitz[14] has proved by experiments with iodized fats that fat may be extracted directly from the blood by the mammary glands and be eliminated with its secretions. Similar observations have been made by Spampani and Daddi with sesame oil.[15] It is also now conceded that fat may be formed from carbohydrates in the animal organism, and it is possible that the milk glands may produce fats from the carbohydrates brought to them by the blood.[16]

Origin of Milk Proteids.—The epithelial cells are rich in proteids and nucleo-proteids, which are probably the sources of the casein or its mother substance, the caseinogen.[16] Basch has attempted to show that the casein is formed in the mammary gland by the nucleic acid of the nucleus set free, uniting the intra-alveolar with the transudated serum, thereby forming a nucleo-albumin, called caseinogen. The origin of the proteids is, however, far from being settled.

Origin of Milk Sugar.—The origin of milk sugar or lactose is not definitely known. Among the nucleoproteids just mentioned is one which yields a reducing substance when boiled with dilute acids, but the relation of this substance to the formation of lactose has not been thoroughly investigated.[16] Muntz believes that milk sugar may be formed in herbivora by syntheses from dextrose and galactose, but this theory does not hold in the case of carnivora which may produce milk sugar even when fed exclusively on a diet of lean meat.[16]

COMPOSITION OF COW'S MILK.—Milk consists of an emulsion of fat in minute subdivision suspended in the milk plasma which consists of milk sugar, or lactose, proteids, extractives, mineral matter, and water. It is therefore apparent that we have represented all the great subdivisions of foodstuffs, that is, fats, carbohydrates, proteids, mineral matter, and water. The proportion in which these substances occur in the milk varies in different animals and also in the same animal at different times.

The average of a large number of analyses made in this country showed the following result:[17]

Fat	4.00 per cent.
Sugar	4.95 "
Proteids	3.30 "
Mineral matter	.75 "
Total solids	13.00 "
Water	87.00 "
	100.00 "

Droop-Richmond[19] gives the composition of cow's milk in England based on the analyses of two hundred thousand specimens as:

Fat	3.90 per cent.
Lactose	4.75 "
Casein	3.00 "
Albumin	.40 "
Mineral matter	.75 "
Water	87.10 "

The analyses of milk by French and German chemists, as well as by many English and American investigators, show varying results, which serve to emphasize the fact, which cannot be too strongly impressed upon the reader, that the composition of milk of large herds of cows, as well as of individual cows, varies sometimes within wide limits of any average that one may attempt to establish. These variations depend upon the breed of cow, the methods of feeding, the health of the animal, the season of the year, and other conditions.

The variation according to the breed is shown in the following table, compiled from average analyses, by Mr. Gordon of the Walker-Gordon Laboratory:

	Durham or Shorthorn.	Devon.	Ayrshire.	Holstein-Friesian.
Fats	4.04	4.09	3.89	2.88
Sugar	4.34	4.32	4.41	4.33
Proteids	4.17	4.04	4.01	3.99
Mineral matter	.73	.76	.73	.74
Total solids	13.28	13.21	13.04	11.94
Water	86.72	86.79	86.96	88.06
Daily quantity	large	moderate	large	very large

	Brown Swiss.	Jersey.	Common native.	American grade.
Fats	4.00	5.21	3.69	4.01
Sugar	4.30	4.52	4.35	4.36
Proteids	4.00	3.99	4.09	4.06
Mineral matter	.76	.71	.73	.74
Total solids	13.06	14.43	12.86	13.17
Water	86.94	85.57	84.14	86.83
Daily quantity	moderate	large	moderate	moderate

Analyses of milk from Guernsey cows closely approach those of the Jersey cow, but with slightly lower percentages of fat.

As it is of much importance to have some average upon which to base our calculations, we may accept the figures of Holt, Adriance, and others, as fairly representative of the average of American milk, bearing in mind, however, that there is a wide variation possible in any individual case.

Fats[20]	4.00 per cent.
Lactose	4.50 "
Proteids	3.50 "
Mineral matter	.75 "

As an illustration of the variations in the percentage composition of milk during the three periods of a milking, we may quote the following analysis by Harrington.[5]

	Fat.	Total solids.	Water.	Mineral matter.
"Fore milk"	3.88	13.34	86.66	0.85
"Middle milk"	6.74	15.40	84.60	.31
"Strippings"	8.12	17.13	82.87	.82

Seasonal and monthly variations in the composition of cow's milk are quite distinct as shown in the following table by Droop-Richmond[19] prepared from analyses covering a period of sixteen years:

Month.	Specific gravity.	Total solids. Per cent.	Fat. Per cent.	Solids not fat. Per cent.
January	1.0322	12.88	4.02	8.86
February	1.0322	12.78	3.93	8.85
March	1.0322	12.71	3.88	8.83
April	1.0322	12.66	3.84	8.82
May	1.0323	12.66	3.82	8.84
June	1.0322	12.59	3.79	8.80
July	1.0317	12.66	3.93	8.73
August	1.0316	12.73	4.02	8.71
September	1.0319	12.92	4.12	8.80
October	1.0322	13.13	4.21	8.92
November	1.0322	13.19	4.30	8.89
December	1.0322	13.04	4.16	8.88

It will be seen from this table that the year may be divided into four periods: 1. In November, December, and January, the milk is rich in both fats and solids not fat. 2. In February, March, and April, the solids not fat do not show much variation, but the percentage of fat is diminished. 3. In May, June, July, and August, the lowest percentage of fat is reached, and the solids not fat also show slightly lower averages. These monthly variations are much less marked in herds, the feed of which is the same throughout the year, and are most marked in herds which are turned out to pasture during the spring and summer.

The evening milk is almost invariably richer than the morning milk if the interval between milkings is from nine to ten hours; but this difference is much less marked if the interval is twelve hours.[19] Other factors which are important in influencing the composition of milk are a change in milkers, variations in the rapidity of milking, rough treatment, exposure to rain or bad weather, and unusual excitement or sickness.

In reference to the influence of feed upon the quality of milk, Farrington, and Woll[25] say: "The increase which has often been observed in the amount of butter produced by a cow, as a result of the change of feed, doubtless, as a rule, comes from the fact that more, but not richer, milk is produced. The quality of milk which a cow produces is as natural to her as is the color of her hair and is not materially changed by any special system of normal feeding." This opinion is in accordance with the conclusion arrived at by the director of the Copenhagen Experiment Station, who has for ten years supervised the feeding of two thousand cows. He states that the change in feed in the different lots of cows has had practically no influence on the chemical composition (fat content) of the milk produced. It is interesting to record that by careful selection and breeding of the best specimens of a given herd of cows, the quality of milk may, in the course of several generations, be raised to a considerably higher standard. There are herds of Holstein cows on the farms of the Walker-Gordon Company which have been carefully selected and bred, which now in the tenth or twelfth generation yield a milk which will average four per cent. of fat, an increase of about one per cent. over the average Holstein milk.

It should be borne in mind that the quality of the milk is not the only factor to be considered. The quantity of milk must always be considered in determining the value of a particular breed of cow for dairy purposes.

Reaction.—Perfectly fresh milk is amphoteric, but cow's milk is relatively more acid than human milk. The acidity is due to the presence of phosphates; the alkalinity to the presence of alkaline carbonates.

Specific Gravity.—The specific gravity varies from 1.028 to 1.0345. It increases very slightly for a few hours due to molecular modification of the casein. It is dependent upon the presence of solids not fat which are in solution, which tend to raise the specific gravity, and on the fat itself which by virtue of its being lighter than water tends to lower the specific gravity. It is lowered by the addition of cream or water and is raised by the removal of cream. The specific gravity of milk is therefore not an absolute test of the quality of milk; for instance, if whole milk of specific gravity 1.032 is separated from its cream, the specific gravity will rise to 1.036, which may be reduced to 1.032 again by the addition of ten per cent. of water. On the other hand, if cream is added to milk of 1.032 specific gravity, so as to raise the fat percentage four per cent., the specific gravity will be lowered to 1.028.[19]

Fats.—The fat of milk exists entirely in the form of the fat globules suspended in the plasma. These globules vary greatly in size. It is a disputed point whether the globules are purely fat. Storch[18] maintains that they are surrounded by a slimy substance which his analyses show to be neither casein nor lactalbumin, but a nitrogenous material containing fourteen per cent. of nitrogen and also a reducing substance on boiling with mineral acids. Others have held the opinion that there is a stratum of caseinogen surrounding each globule and held to it by molecular attraction, thus preventing the globules from uniting with one another. On shaking milk with ether, the fat is separated but slowly; but when the caseinogen is precipitated by alkalies, acids, or rennin, the solution of the fat in ether is easily obtained. The percentage of fat in milk, as seen above, varies according to the breed of the cow, the season of the year, the feed, and many other conditions. Four per cent. is taken as a fair average of good milk.

The non-volatile milk fat consists chiefly of palmitin, stearin, and olein, the source of butter. The volatile class is composed of butyric acid, caproic acid, and small traces of myristic acid, caprilic acid, capric acid, lauric acid, and arichidic acid. Lecithin, cholesterin, and a yellow coloring matter are also present.[16] The butyric and caproic acids constitute over seven per cent. of the whole fat.[1]

Milk Plasma.—Milk plasma contains in solution, or pseudo-solution, the remaining constituents of milk, that is the milk sugar or lactose, the proteids—caseinogen, lactalbumin, lactoglobulin—and the mineral matter. These proteid substances are of complex composition, containing C, O, N, H, P, and S, but the composition of the proteid molecule is not known. Certain extractives are also present; that is, faint traces of urea, creatin, creatinin, xanthin, lecithin, cholesterin, and citric acid. The gases of milk consist chiefly of CO_2, N, and traces of O.[16]

Milk Sugar or Lactose.—Lactose is found in nature in milk alone, but has been detected pathologically in the urine of pregnant women. It occurs ordinarily as colorless, rhombic crystals with one molecule of water of crystallization. When heated to 170–180° C. it is converted into lactocaramel, but when heated in solution it begins to undergo decomposition at 70° C., which is a point of some significance in connection with the subject of sterilization of milk in infant feeding. It is less sweet and less soluble than dextrose, it dissolves in six parts of cold or 2.5 parts of hot water, but is insoluble in ether and absolute alcohol. Solutions of lactose are dextrogyrate (+ 52.5°).

Milk sugar does not undergo alcoholic fermentation with pure yeast, but is fermentable by the action of certain schizomycetes and by the enzyme *lactase* which exists in yeast, being split by hydrolytic cleavage into glucose (dextrose) and galactose. The manufacture of "koumyss" from mare's milk and "kephir" from cow's milk is based upon the above facts. Lactose readily undergoes lactic-acid fermentation as already described. Lactose is not acted upon by invertase, diastase, rennin, pepsin, or trypsin.[19]

Chemically, lactose has the property of reducing Fehling's solution, but like maltose it fails to respond to Barfoed's test. It may be distinguished from maltose by the characteristic burr-like ozazones, formed by heating with phenylhydrazin acetate. Commercially it is prepared by extraction from sweet whey, a by-product in the manufacture of cheese.

Caseinogen.—Caseinogen is the term applied to the chief proteid of milk when in a state of solution. After precipitation, it is more correctly spoken of as casein. It constitutes eighty per cent. of the total proteids, and amounts to about 2.8 per cent.[30] It is a nucleo-albumin and occurs only in milk. Whether the caseinogen from different kinds of milk is identical has been the subject of considerable investigation and discussion. The analyses of the casein of human milk and cow's milk by Hammarsten and Wroblewsky show certain marked differences in the proportions of C, H, N, P, S, and O, but it is by no means certain as to how much these differences affect the digestibility of the two caseins. Szontagh[23] maintains that human milk yields no pseudo-nuclein in pepsin digestion, and hence the caseinogen cannot be a nucleo-albumin like that of human milk.

Caseinogen is coagulated by the rennin ferment in the presence of enough and not too much calcium salts. In the absence of calcium coagulation does not take place, but the rennin effects a change in the casein so that even

if it is killed by heat the casein will coagulate when the calcium salts are supplied,[16] showing that the lime salts are necessary only for the separation of the curd. According to Hammarsten, the caseinogen, in rennin coagulation, is split into an insoluble body, paracasein or curd, which is the chief product, and into a soluble substance similar to albumose, called "whey proteid," which is formed only in very small amounts. This paracasein has not the property, possessed by caseinogen, of holding the calcium phosphate of the milk in solution, and the latter is precipitated in considerable quantities in the curd. The soluble lime salts alone are of much importance in the coagulation of the caseinogen.

Caseinogen is not coagulable by heat, in marked contrast to the other proteids, lactalbumin and lactoglobulin. It is, however, coagulated by small amounts of acetic acid or mineral acids and is soluble again in an excess of the acid. The acid solutions thus obtained are again precipitated by strong mineral acids in excess.

Caseinogen is precipitated from neutral solutions by ammonium sulphate, sodium chloride, and magnesium sulphate when added to full saturation, without changing its properties. It is also precipitated from neutral solution by metallic salts.

Lactalbumin.—The lactalbumin, including the small traces of lactoglobulin, and of the other nitrogenous extractives, form about twenty per cent. of the total proteids of milk or 0.70 per cent.[30] In human milk, it is of much greater importance, constituting two-thirds of the total proteids (König). It is characterized by its property of coagulating at 72° to 84° C., the degree depending upon the amount of salt in solution. It is not coagulable by dilute acids or rennin. It is very similar chemically to serum albumin but has a lower specific rotatory power (– 37°). It is not precipitated by magnesium sulphate added to saturation nor by half saturation with ammonium sulphate. When heated at the above temperature it is not entirely coagulated, but is so changed that it is readily precipitated by magnesium sulphate.

Other Nitrogenous Substances in Milk.—Various laboratory products may be produced from the proteids of milk, such as albumose, peptone, and lactoprotein, but it has not been proved that they occur in nature.[16] Lactoprotein is a mixture of casein and changed albumin. Storch has described a nucleo-proteid which also occurs in milk in minute traces.

A part of the nitrogen of milk exists as extractives and is estimated as the difference between the total nitrogen contents and the protein nitrogen. This difference, according to Munk's analyses, amounts in cow's milk to about one-sixteenth of the total nitrogen and in human milk to one-tenth of the total nitrogen.[16] The extractives consist chiefly of xanthin, creatin, creatinin, lecithin, cholesterin, and urea.

	Harrington and Kinnicutt.[5] Human milk.	Richmond.[20] Cow's milk.
Lime	15.69	20.27
Magnesia	1.92	2.80
Potash	24.77	28.71
Soda	9.19	6.67
Phosphoric acid	10.73	29.33
Chlorine	20.11	14.00
Carbonic acid	7.97	.97
Sulphur	2.19	A trace.
Ferric oxide and alumina	.40	.40
Silica	.70	
Oxygen (calculated)	6.16	
Unconsumed carbon	.71	
Total	100.54	103.15
Less oxygen and chlorine	......	3.15

Mineral Matter.—The total mineral matter obtained by the analyses of König[16] was 0.70 per cent. It consists chiefly of K, P, Ca. Cl, and S, with very small traces of Si, Fe, and Mg. A part of the calcium is combined with casein, the remainder with phosphoric acid. The preceding table represents the results of two different investigations of the mineral matter of cow's milk as compared with human milk.

A comparison of the salts of human and cow's milk is seen in the following table:[20]

Human Milk—Harrington and Kinnicutt.	Per cent.
Sodium chloride	21.77
Potassium chloride	12.05
Potassium sulphate	8.33
Potassium carbonate	23.47
Calcium phosphate	23.87
Calcium carbonate	2.85
Calcium sulphate	2.25
Calcium silicate	1.27
Iron oxide and alumina	.37

Cow's Milk—Adapted from Söldner.	Per cent.
Sodium chloride	10.62
Potassium chloride	9.16
Potassium citrate	5.47
Potassium phosphate	21.99
Calcium phosphate	16.32
Calcium citrate	23.55
Lime combined with proteids	5.13
Magnesium citrate	4.05
Magnesium phosphate	3.71

The chief differences between the above analysis of Harrington and Kinnicutt and all other analyses of human milk are as follows[5]: (1) The phosphoric acid is less than half as much as previously reported. (2) The magnesium is also less than half as much. (3) Silica and alumina are present. The analyses were made from six quarts of human milk collected by Rotch and his assistants from a large number of nursing mothers. This represents an unusually large amount of breast milk for experimental purposes, and the results are therefore of exceptional value. It has not been found practicable, however, to make use of these differences in the mineral matter of human and cow's milk in the adaptation of cow's milk to infant feeding.

Gases.—Oxygen, nitrogen, and carbon dioxide are present in fresh milk and are probably due to absorption from the air. Boiling and sterilization of milk in open bottles causes the carbon dioxide to volatilize, and to this fact, rather than to chemical changes, is due the unpleasant taste of milk heated in open vessels. The pleasant taste can be restored if carbon dioxide is artificially incorporated with the milk. A large portion of the gas also disappears in centrifugation of milk.[21]

Action of Heat on Milk.—When milk is heated to 70° C. a certain amount of the lactalbumin and lactoglobin is coagulated, but the major part of the lactalbumin is converted into a form which is precipitated by acids, by magnesium sulphate, and by the other precipitants of casein which do not act upon the lactalbumin in its natural state. At 80° C. certain organized principles undergo a change, the nature of which is not known, but the evidence of which is found in certain chemical reactions.[17] At 100° C. calcium citrate is deposited, some oxidation of the sugar takes place, and a deposition of albumin and certain salts on the fat globules occurs, causing the latter to rise and coalesce.

At temperatures exceeding 60° C. a skin is formed on the surface of the milk, consisting probably of an oxidized product of casein together with calcium salts and some fat. When heated above 70° C. the taste and smell of milk are altered.

Fresh amphoteric milk does not coagulate on boiling, but when lactic-acid fermentation has proceeded sufficiently far coagulation occurs on the application of heat —a phenomenon often noticed in summer when the conditions are especially favorable to lactic-acid fermentation. This is probably due to the acid developed displacing the casein from its combination with an alkali, the free acid manifesting its properties.[19] Lactic-acid fermentation is checked by the action of heat.

Heat does not destroy the ptomaïns or toxins which have been formed by the growth of micro-organisms in milk; it only checks for a variable length of time the growth of bacteria with their deleterious products; hence the pasteurization or sterilization of an already contaminated and infected milk can never make up for a lack of a clean, uncontaminated milk supply.

According to H. Bitter[11] all pathogenic germs are killed with certainty at a temperature of 68° C. (154.4° F.) continued for one-half hour, and the milk is thereby not

altered in taste or appearance. Ordinarily twenty minutes' exposure is sufficient. Most bacteria are killed at from 60° to 64° C. (140°–147° F.), but Theobald Smith[12] has demonstrated that the tubercle bacillus may survive an exposure for one hour at 65° C. (149° F.), so that these lower temperatures are not to be relied upon. The spores of the bacteria, however, and some of the casein ferments are not destroyed by a single pasteurization. Sterilization of milk under pressure for two hours at 120° C. (248° F.) is sufficient to destroy spores.[1] At such temperatures, however, the sugar is converted into caramel, many of the natural ferments are destroyed, the casein is partially precipitated, and in the opinion of many the nutritive value of the milk is seriously interfered with. A temperature 68.3° C. (155° F.) is the temperature which may most profitably be relied upon for the pasteurization of milk. It is sufficiently high to kill most of the organisms which are found in milk, and at the same time does not produce any chemical changes that may be detected in the milk.

It is not known with certainty, despite the many opinions expressed on the point, as to how far the heating of milk affects its digestive qualities. A heated milk is curdled less readily by rennin than is unheated fresh milk, but there is reason to believe that this is due to the deposition of the calcium salts rather than to any change in the casein.[19] On the other hand it has been claimed that sterilized milk is easier of digestion in the stomach and does not produce so firm a clot.

Effect of Cold on Milk.—Cold is a most important factor in preventing the growth of bacteria in milk. If the temperature is sufficiently low, about 15.5° C. (31° F.), the milk will freeze. The frozen portion does not show the same composition as the milk itself, but contains a larger proportion of water.

The preservation and adulteration of milk will be considered under another heading, bearing on the relation of milk to the public health.

Separated Milk.—Separated milk is the term applied to a milk from which the fat has been wholly or partially removed, either by the centrifuge or by gravity.[5] Obviously, therefore, it has no constant composition. Milk from which the fat has been removed by the ordinary process of skimming contains from 0.4 to over two per cent. of fat.[19] The proportions of the other ingredients depend upon the proportion of fat removed. They are increased by the removal of the fat. If the centrifugal separator is worked to its maximum capacity practically all the fat is separated out as cream, leaving a slimy residue, and the milk plasma, and to the latter the term "fat-free milk" is now given.[5] Many analyses of this fat-free milk at the Walker-Gordon Laboratories have shown the fat to be approximately only 0.05 per cent. About the same percentage of fat (0.05) is to be found in the lowest eight ounces of a jar of milk which has been setting eight or twelve hours, so that a milk practically fat-free can be obtained both by gravity and by centrifugal methods.

The slimy residue mentioned above consists of 0.04 part in one hundred parts of milk separated, and in very contaminated milk the proportion may be as high as 0.15 per cent. In consists of inorganic impurities such as dirt, vegetable matter from the fodder, substances from the cow, such as hair, pavement cells from the udder, empty gland cells, micro-organisms, and sometimes pus and blood. While centrifugal cream is much cleaner than the milk from which it is derived, the process of separation does not materially diminish the number of micro-organisms.[19]

Creams.—Cream is the term applied to the separated part of the milk which is especially rich in fat. It is of the same qualitative composition as milk, but with different proportions of the ingredients. The richer the cream is in fat, the lower is its percentage of proteids and sugar. The following table, based on analyses by Adriance and others, represents with a fair degree of accuracy what we may assume to be the composition of creams of different density.[20]

	I. Per cent.	II. Per cent.	III. Per cent.	IV. Per cent.	V. Per cent.	VI. Per cent.
Fat	4.00	8.00	10.00	12.00	16.00	20.00
Sugar	4.50	4.35	4.30	4.20	4.05	3.90
Proteids	3.50	3.40	3.35	3.30	3.20	3.05
Salts	.75	.70	.67	.65	.60	.55

The above represents a somewhat lower average of proteids than was formerly accepted, but Rotch, Holt, Adriance, and others consider these figures more accurate than the four per cent. of proteids formerly accepted as the standard of average whole milk.

One hundred and ten analyses at the Walker-Gordon Farm have shown that if the mixed milk, containing four per cent. fat, be bottled and immediately cooled, the upper eight ounces will, after four hours, contain nearly all the fat that will rise as cream, and that the upper layers of fat will have nearly the same percentage of fat whether the fat has stood for four hours, for eight hours, or over night.[20]

Assuming that the milk contains four per cent. of fat, we may secure different percentages of cream with approximate accuracy under the following conditions:

Fat in the upper	16	ounces after setting	6	hours =	7 per cent.
" " "	8	" " "	6	" =	10 "
" " "	10	" " "	8–12	" =	10 "
" " "	8	" " "	8	" =	12 "
" " "	6	" " "	8	" =	16 "
" " "	4	" " "	4–6	" =	20 "

If the milk is known to be rich in fat (five per cent. or over), from two to three ounces more should be removed for each formula, and if poor in fat (three per cent.) about two ounces less than the specified amount. The accuracy of the above statements is by no means absolute, as the results depend upon many varying conditions, but the figures represent a fair average of the investigations of Rotch, Holt, Chapin, the Walker-Gordon Laboratory, and others. Creams of thirty-two and forty per cent. of fat, and even higher may be obtained by means of centrifugal separators.

Bacteriology of Cow's Milk.—Under this heading we may consider briefly the chemical action of micro-organisms and ferments upon the composition of milk. Their influence in the transmission of disease and their relation to the public health will be separately treated.

Richmond[19] makes the following practical dairy classification of the micro-organisms which may be found in milk:

I. Micro-organisms acting on milk sugar causing fermentation.
- (*a*) with the production of lactic acid.
- (*b*) with the production of butyric acid.
- (*c*) with the production of alcohol.

II. Micro-organisms acting on proteids.
- (*a*) Curdling milk without acidity and not dissolving the curd.
- (*b*) Curdling milk without acidity and afterward dissolving the curd.
- (*c*) Peptonizing the proteids without curdling the milk.

III. Micro-organisms producing coloring matter.

IV. Micro-organisms having no direct action on the milk.

V. Micro-organisms which are pathogenic, giving rise to specific pathological conditions.

The line between these groups cannot always be sharply drawn; one variety may belong to two or more groups. Conn,[26] in a series of investigations covering a period of ten years, has isolated over two hundred different types of bacteria. The large number of micro-organisms is explained by the great exposure to infection which milk undergoes from the time it leaves the milk ducts of the udders to its final disposition as an article of food, and also by the fact that milk is one of the best culture media for the growth of bacteria we have, containing, as it

does, in an assimilable form, all the varieties of food necessary for the sustenance of life.

It is quite possible to obtain cow's milk which is practically sterile by throwing away the first portions of milk withdrawn from the teats, as bacteria penetrate more or less deeply from the outside into the ducts of the teat. Practically, nearly all of the bacteria come from without, although there is evidence that in the case of tuberculosis and sepsis elsewhere in the body the tubercle bacilli and septic bacteria may find entrance into the milk through the mammary gland. (Consult also p. 840.)

Lactic-Acid Fermentation.—Fermentation of the lactose with the production of lactic acid and subsequent coagulation of the caseinogen by the lactic acid, is one of the most common changes which milk undergoes. This process is the ordinary souring of milk. It is due to Hueppe's "bacillus of lactic acid," which seems always to be present. Over one hundred other kinds of bacteria seem to have this same property.[2] The "bacillus lactis aerogenes" described by Escherich is closely allied to Hueppe's bacillus and also to the bacillus coli communis, which has the same power of inducing lactic-acid fermentation. The organisms belonging to this group are considered by Marfan to be varieties of the bacillus coli communis and like the latter may at times become pathogenic. They are easily killed at low temperatures, and their growth is checked when lactic acid has been formed to the extent of one per cent. According to Biedert, Escherich, and Richet, the formation of lactic acid by the bacillus lactis aerogenes prevents the other forms of fermentation in the stomach and intestines.

Butyric-Acid Fermentation.—When butyric-acid fermentation occurs, the milk coagulates, but the casein may be redissolved. The butyric acid which is formed can usually be detected by its unpleasant, characteristic odor. It is caused by many micro-organisms, but does not occur readily in the presence of lactic acid.

Alcoholic Fermentation.—Alcoholic fermentation does not readily occur in milk, except in very small quantities as by-products of the growth of certain micro-organisms.

Succinic-Acid Fermentation may take place as a result of the decomposition of milk by certain forms of bacteria.

The so-called casein ferments or peptonizing bacteria are saprophytes, belonging to the groups of which the bacillus subtilis and the bacillus mesentericus vulgatus are the prototypes.[27] They act on the casein at the end of lactic-acid fermentation through certain enzymes which they are supposed to secrete, and which resemble rennin. They coagulate caseinogen without the production of acids. Some of them have the property of liquefying the casein coagulum. Duclaux calls this ferment "casease" and the resulting peptones "caseone." Still other varieties peptonize the proteids without the preliminary process of coagulation. Leucin, tyrosin, urea, and the other products of advanced intestinal digestion are formed.

The peptonizing bacteria are very resistant to the action of heat and may survive a temperature of 100° C. for three-quarters of an hour.[28] They are directly antagonized by lactic acid; hence the lactose of milk has a tendency to check the growth of putrefactive bacteria in that it favors the development of lactic-acid-producing bacteria.

The micro-organisms which ferment milk without curdling it act also by the secretion of a proteolytic enzyme. In these cases, the milk becomes more and more translucent until it assumes an appearance like liquid jelly.[19]

Another group of bacteria gives rise to the so-called "milk anomalies." Briefly enumerated they are as follows:

Red Milk. This is caused by saprophytic (non-pathogenic) bacteria, such as the sarcina species, the bacillus prodigiosus, the bacillus lactis erythrogenus, the bacillus rubidus, the spirillum rubrum, the micrococcus cinnabareus, and a red yeast.

Yellow Milk. This is caused by the bacillus synxanthus.

Blue Milk. This is caused by the bacillus cyanogenus, the bacillus cyaneofluorescens Zangemeister, and the bacillus janthinus.

Slimy Milk. This is caused by the micrococcus viscosus (Weigman and Zion, G. Leichman).

Bitter Milk. This is caused by the proteus vulgaris Hauser, by the bacillus von Bleisch, by the bacillus and micrococcus liquefaciens lactis amari Freudenreich, and by bacteria described by Hueppe, Flügge, and von Stirling. This reaction is due to the formation of peptones, as may be demonstrated by the biuret reaction.

Poison Milk. This name is given to milk which acts like alkaloids upon animals. It is due to the presence of ptomaïns or toxins produced by bacteria from the albuminoids of the milk. Under certain conditions benzin derivatives are formed, the most important of which is a diazo-benzin, called *tyrotoxicon*, which was isolated by Vaughan, of Ann Arbor, Mich. It is the exciting cause of the toxic symptoms observed in cases of milk poisoning, cheese poisoning, and ice-cream poisoning. *Spasmotoxin* is a similar toxic product found by Brieger in putrefied milk.[19]

Finally we may mention the bacillus of typhoid, the tubercle bacillus, the bacillus of diphtheria, the spirillum of Asiatic cholera, the organism of cholera infantum, the infectious agent of scarlet fever and smallpox, and other varieties of organisms, all of which may find in milk a favorable ground for growth and transmission and prove the source of epidemics in communities. This aspect of the subject will receive due attention in the consideration of milk in its relation to the public health.

COLOSTRUM.—Colostrum is the term applied to the milk which is secreted in the early days of lactation before the equilibrium of the mammary gland has become established. It is characterized by the presence in the milk of the so-called "colostrum corpuscles." These cells measure from 12 to 22 mm. in diameter. They have a small, irregular, extensively degenerated nucleus. The protoplasm contains large and small granules which show the proteid reactions and are not stained by acids, basic or neutral dyes. A few of the granules stain by osmic acid and probably represent fat. Leucocytes are also apt to be present. Czerny considers the colostrum corpuscles lymphoid cells whose function is to absorb and reconstruct unused milk globules and to convey them from the milk glands into the lymph channels. In general, colostrum of cow's milk contains low fats and proteids and high sugar. As lactation becomes established the fats, proteids, and mineral matter increase and the sugar diminishes, the reverse of what occurs in human milk.[19]

Harrington's analysis of the colostrum milk of a cow gives the following composition[5]:

Fat	1.71	per cent.
Milk sugar	4.90	"
Proteids	1.72	"
Mineral matter	.78	"
Total solids	9.11	"
Water	90.88	"
	100.00	"

The human colostrum period covers an interval of about two weeks. It is characterized by fat percentages which may be very low or very high, by low sugar percentages which rapidly increase, and by high proteid percentages which rapidly diminish. These variations are not constant, however. Different analyses show different results. Woodward has analyzed the colostrum of six nursing women, using in each instance the combined twenty-four hours' amount of the middle milk, and following each case for from three to seven days. He found that colostrum corpuscles were not always present in so-called colostrum milk, and that when they were present the percentage of proteids was higher, and as they disappeared the percentage of proteids diminished. The results of his analyses are seen in the following table:

		General average of twenty-six analyses.
Color	Yellowish.	
Reaction	Alkaline.	
Specific gravity	1.024 to 1.034.	1.0295
	Per cent.	Per cent.
Fats	2.0 to 5.3	4.0
Proteids	1.64 to 2.22	1.9
Ash	.14 to .42	.2
Total solids	10.18 to 13.65	12.5
Lactose (calculated)	5.6 to 7.4	6.5
Water	....	87.5

If the colostrum corpuscles continue into the third week, or if they return at any time during lactation, they almost invariably cause disturbance of the infant's digestion and become an indication for a temporary suspension of nursing.[5] In normal lactation, the breast milk has generally established itself by the fifteenth day.

Human Milk.—Many points bearing on the subject of human milk have been fully considered under cow's milk, to which the reader is referred.

Owing to the high nervous organization of the nursing mother, we find a much more unstable mechanism in the mammary glands of women. As a result, there are greater variations in the quantity and quality of human milk than in cow's milk. Alterations in the composition occur not only from day to day but from hour to hour, and also during the different periods of nursing.[5] The variations are even more marked when due to pathological or abnormal conditions. In reference to this point, the reader is referred to Rotch's "Pediatrics," 1901, in which are given a large number of interesting cases showing changes in the composition of breast milk from a variety of causes, and the results obtained by removing the disturbing element affecting the mother. The composition of a particular breast milk has individual characteristics, especially as to its nitrogenous and fat percentage, hence it is sometimes misleading to attempt to judge the quality of a given specimen by comparing it with the mean of many analyses.

	Pfeiffer.	Leeds.	Johanneson.	Richmond.
Number of cases	160	80	25	90
Fat	3.11	4.13	3.21	3.07
Sugar	6.3	6.93	4.67	6.59
Proteids	1.94	1.99	1.1	1.97
Mineral matter	.19	.2	....	.26
Water	88.22	86.73	....	88.04
Solids	11.76	13.26	....	11.94

	Lehmann.	Meigs.	Schlossman.	Adriance.
Number of cases	40	43	218	120
Fat	3.8	4.28	4.83	3.83
Sugar	6.0	7.4	6.95	6.56
Proteids	1.7	1.05	1.56	1.3
Mineral matter	.2	.1	....	.2
Water	88.5	87.16	....	87.8
Solids	11.7	12.83	....	12.2

The preceding table shows the results of the analyses of breast milk by various investigators.[20]

The above analyses of Schlossman and Adriance cover the entire period of lactation and follow uniform methods, and are therefore better averages than the other analyses which cover shorter periods of lactation.

The very great variations noted in many of the series of analyses of human milk by different competent investigators is probably in large part explained by differences in the methods of analyses, in the hygienic surroundings and food of the mother, and especially in the portion of breast milk analyzed, whether from the fore-milk, middle milk, or strippings.

Droop Richmond concludes from a careful consideration of a large number of reliable analyses that a fair mean average for normal human milk after the regularity of lactation has become established is[20]: Fats, 3.3 per cent.; sugar, 6.8 per cent.; proteids, 1.5 per cent.; mineral matter, 0.2 per cent.

That there may be great variations from this mean in health is shown by the following instructive analyses, quoted by Rotch,[5] of breast milk of healthy mothers, whose infants were digesting well and gaining. An apparently poor milk may suit one individual infant and cause marked disturbance in another. Moreover, it does not follow that a theoretically ideal breast milk will supply the demands of every infant.

	I. Per cent.	II. Per cent.	III. Per cent.	IV. Per cent.	V. Per cent.	VI. Per cent.	VII. Per cent.	VIII. Per cent.	IX. Per cent.	X. Per cent.	XI. Per cent.	XII. Per cent.	XIII. Per cent.	XIV. Per cent.
Fat	5.16	4.88	4.84	4.37	4.11	3.82	3.80	3.76	3.30	3.16	2.96	2.36	2.09	2.02
Sugar	5.68	6.20	6.10	6.30	5.90	5.70	6.15	6.95	7.30	7.20	5.78	7.10	6.70	6.55
Proteids	4.14	3.71	4.17	3.27	3.71	1.08	3.53	2.04	3.07	1.65	1.91	2.20	1.58	2.12
Mineral matter	.17	.19	.19	.16	.21	.20	.20	.14	.12	.21	.12	.16	.15	.15
Total solids	15.15	14.98	15.30	14.10	13.93	10.80	13.68	12.89	13.79	12.22	10.77	11.82	10.32	10.84
Water	84.85	85.02	84.70	85.90	86.07	89.20	86.32	87.11	86.21	87.78	89.23	88.18	89.68	89.16
	100.00	100.00	100.00	100.00	100.00	100.00	100.00	100.00	100.00	100.00	100.00	100.00	100.00	100.00

The color of milk is no indication as to the composition of the specimen. A chalky white specimen may be rich in fat, and a yellowish sample may be poor in fat.

Reaction.—Woman's milk is amphoteric in reaction, but, as shown by Courant, is relatively more alkaline than cow's milk. The relationship between the alkalinity and acidity is as 3:1, as compared with 2.1:1 in cow's milk.[16]

Fats.—The fat percentages vary normally between three and four and one-half per cent. Fat is the most variable constituent of human milk. It is relatively poorer in volatile acids than cow's milk, and is in a finer state of emulsion. Richmond has found that the fat in the early part of lactation is different from that toward the close of lactation.

Lactose.—The percentage of lactose or sugar in human milk is the most constant of all the ingredients, ranging between six and seven per cent. It is lowest during the colostrum period. There seems to be a steady but slight increase in the percentage during lactation.

Proteids.—The normal proteids of breast milk may be assumed to range between one and two per cent., but as will be seen later this is subject to wide variations from very slight causes. According to some analyses by Pfeiffer, Schlossman, and Adriance, they normally reach their highest point during the early weeks of lactation and then gradually diminish until at the end of the first year they rarely exceed one per cent.

	Woman's milk.	Cow's milk.
Caseinogen	0.59 per cent.	2.88 per cent.
Lactalbumin	1.23 "	.53 "

According to König,[5, 6, 8] there is a marked difference between cow's milk and human milk not only as regards

the total quantity of proteids, but also as regards the relative proportion of caseinogen and lactalbumin. This is seen in the preceding table.

In other words, approximately two-thirds of the total proteid in human milk is in the soluble non-coagulable form of lactalbumin and the remaining one-third is in the coagulable form. In cow's milk, on the contrary, we see that the caseinogen is greatly in excess of the lactalbumin. As the caseinogen is the proteid which gives rise to the large, tough curds which cause so much disturbance in the artificially fed infant, we can readily see wherein the coagulum of cow's milk is so difficult for the infant to digest. Rotch, Westcott, White, and Ladd have recently laid much stress upon this difference in the relative proportions of the two proteids in its application to infant feeding. According to some analyses, however, caseinogen is in excess of lactalbumin even in human milk, but nearly all are agreed in the relatively greater proportion of lactalbumin or soluble proteids in human milk as compared with cow's milk. The great majority of analyses of breast milk do not attempt to give anything more than the total proteids.

It is also probable that there are qualitative differences in the caseins of cow's milk and human milk, already mentioned under cow's milk, but whether these differences in composition of the casein molecules account for the differences in the character of the coagula of the two milks, or whether the differences are due to the unequal relationship of the casein and salts in the two kinds of milk, is not determined. White and Ladd[6] have shown that when cow's milk is so modified by the addition of whey and cream as to correspond in its proportions of caseinogen and lactalbumin to that of human milk, the coagulum obtained by the addition of rennin or acids is not coarse and tough, but fine and flocculent, resembling that of mother's milk.

Mineral Matter.—The difference between human milk and cow's milk as regards the mineral matter which each contains, has already been considered in part under cow's milk. As lactation advances, the percentage of salts in mother's milk diminishes; but the loss is compensated by the increased quantity of milk secreted. Nearly all the phosphorus in human milk exists in organic combination, while in cow's milk it is in inorganic combination.

Factors Influencing the Composition of Breast Milk.—The influence of food on the composition of human milk is of much importance in infant feeding. An insufficient diet decreases the quantity of milk and the quantity of solids, while an abundant diet increases both. Food rich in proteids increases the fats especially. Food rich in fats, if digested well, may also increase the fat percentage. The presence of large quantities of carbohydrates in the food seems to cause no direct action on the quantity of the constituents of milk. Watery food increases the quantity of milk but diminishes the relative amount of solids.[16]

The following analyses of Rotch's show the influence of a luxurious life on a poorly fed but healthy wet-nurse, and the results obtained by the regulation of the food and exercise.[5]

	I. Normal.	II. Two days before change of food.	III. Rich food and but little exercise for one month.	IV. Food and exercise regulated.
Fats	4.00	0.72	5.44	5.50
Sugar	7.00	6.75	6.25	6.60
Proteids	1.50	2.53	4.61	2.90
Mineral matter	.15	.22	.20	.14
Total solids	12.65	10.22	16.50	15.14
Water	87.35	89.78	83.50	84.86
	100.00	100.00	100.00	100.00

The influence of an excessively nervous temperament upon the composition of the breast milk may be illustrated by the following analyses of the milk of two nursing mothers whose nervous systems were greatly disturbed[5]:

	I.	II.
Fats	0.62	1.62
Sugar	5.80	6.10
Proteids	4.21	3.54
Mineral matter	.20	.17
Total solids	10.83	11.43
Water	89.17	88.57
	100.00	100.00

Pathological variations in human milk, as shown by the above and many other analyses, affect chiefly the proportions of fats and proteids, the former as a rule being diminished and the latter increased. An exception to this statement is sometimes seen in certain mothers who are taking a rich diet and little exercise. In these cases the fats and proteids are both high. The percentages of sugar and mineral matter are not as a rule markedly altered.

Rotch[5] gives the following general rules by which the normal conditions of breast milk may, in many cases, be controlled:

I. To increase the total quantity: Increase proportionately the liquids in the mother's diet and encourage her to believe that she will be enabled to nurse her infant.

II. To decrease the total quantity: Decrease proportionately the liquids in the mother's diet.

III. To increase the total solids: Shorten the nursing intervals; decrease the exercise; decrease the proportion of liquids in the mother's diet.

IV. To decrease the total solids: Prolong the nursing intervals; increase the exercise; increase the proportion of liquids in the mother's diet.

V. To increase the fat: Increase the proportion of meat in the diet and of the fats which are in a readily digestible and assimilable form.

VI. To decrease the fats: Decrease the proportion of meat in the diet.

VII. To increase the proteids: Decrease the exercise.

VIII. To decrease the proteids: Increase the exercise up to the limit of fatigue for the individual.

Bacteriology of Human Milk.—Cohn and Newmann have examined the milk of forty-eight healthy mothers and found bacteria in forty-three cases. The variety found was confined chiefly to the staphylococcus pyogenes aureus and albus and the streptococcus pyogenes. The number present was always greater in the breasts in which the milk was stagnant. The organisms undoubtedly find their entrance through the ducts of the nipple, for the milk toward the end of the nursing is practically sterile.

Milk of Other Animals.—The milks of the goat, ass, and mare have been advocated from time to time as more suited to human infants than cow's milk and in some countries they are more or less extensively used. With the evolution in this country of the idea of percentage modification of cow's milk, the knowledge of infant feeding has been so advanced that there is little prospect that these animals will ever come into extensive use for the purpose suggested. Whereas in some respects these milks resemble human milk more closely than does cow's milk, they still differ to such a degree that modification of the milk would necessarily be practised, and such modification would involve the same principles as those which are applied to cow's milk, and present the same difficulties. The only milks, therefore, of practical value to the physician are human milk and cow's milk. It will not be unprofitable, however, to submit the following table, compiled from Hammarsten and Leffmann and Bean, for purposes of comparing the milks of other ani-

mals with each other and with those of human and cow's milk as already described:

	Fat.	Sugar.	Proteids.	Mineral matter.	Total solids.
Dog	9.57	3.19	9.91	0.73	24.56
Cat	3.33	4.91	9.08	.58	18.37
Elephant	19.57	8.84	3.09	.65	32.15
Porpoise	45.80	1.33	11.19	.57	58.89
Mare	1.09	6.65	1.89	.31	9.94
Goat	4.3	4.0	4.6	.6	13.5
Ass	1.6	6.1	2.2	.5	10.4
Ewe	6.8	4.8	6.3	.8	18.7
Sow	4.8	3.4	1.3	.9	15.4

Witches' Milk.—Witches' milk is the term applied to the secretion of the mammary gland which is sometimes seen in new-born infants of either sex soon after birth. It shows on analysis fractions of one per cent. of fat, sugar, and proteids.

Analysis of Milk.—To determine whether a given fluid is milk, it is only necessary to isolate the constituent elements, namely, fat, casein, and lactose.

The problem which usually confronts the chemist is, however, not the identification of a fluid as milk, but the determination of the quality of the milk. The methods employed for the qualitative analysis of milk are so numerous that they cannot all be considered here. We shall describe only the chief points in connection with the methods most frequently used. In estimating the quality of a given specimen of milk we shall find it necessary to make a qualitative determination of the specific gravity, the total solids, the mineral matter or ash, the fat, the sugar, and the proteids. The detection of preservatives and adulterations will be considered elsewhere.

Determination of the Specific Gravity.—The specific gravity is estimated by means of the lactodensimeter or lactometer, an accurately graduated hydrometer, the scale of which will show specific gravities ranging from 1.015 to 1.040. The milk must be thoroughly mixed, care being taken to avoid the enclosure of air by too much shaking. If bubbles form, the density of the milk is lessened and time must be allowed for the air to rise to the surface and escape. The instrument is inserted gently into a cylindrical tube of sufficient height and diameter to allow it to float freely, and the reading is taken at the actual level of the fluid and not at the point of the stem to which it is drawn by capillary attraction. The specific gravity varies with the temperature of the fluid, and as the lactodensimeter is graduated to 59° F., the milk must either be raised to this point or a correction made for the difference between the actual and the standard temperature. If the milk is above 59° F. the actual reading will be too low; if below, it will be too high. Approximately accurate corrections for differences in temperature can be made by the deduction of one-half of a degree of gravity for each five degrees of temperature below 59° F., or by the addition of the same amount for each four degrees above 59° F.

When only small amounts of milk are available for examination, and when more accurate determinations of the specific gravity are desired, the *pyknometer* or *specific gravity bottle* may be used. This pyknometer has, as a rule, a capacity of 50 c.c. It is dried and weighed and then filled with distilled water, usually at a temperature of 17.5° C. and then weighed again. After rinsing it is dried and filled with milk at the same temperature, and weighed again. The specific gravity is thus easily calculated by dividing the weight of the milk by the weight of the water.

Determination of the Total Solids.—A. Five grams of milk are placed in an accurately weighed flat-bottomed platinum or porcelain dish, heated on a water-bath for one and a half hours, and then placed in a hot-air bath maintained at 100° C. until the weight is constant. The dish is then cooled in a desiccator and weighed. The final weight thus obtained, less the weight of the empty dish, represents the total amount of solids in 5 gm. of milk, and if this be multiplied by twenty the result will express the percentage of total solids.

B. The Babcock Asbestos Method. A definite amount is placed in an accurately weighed cylinder of perforated metal, or into a filter paper cartridge, loosely filled with freshly ignited woolly asbestos. The cylinder is then subjected to a temperature of 100° C. until the weight is constant, when it is cooled and weighed. The gain in weight represents the amount of total solids, from which the percentage is easily calculated.

C. Formula for estimation of total solids. Hehner and Richmond have worked out a formula by which the total solids may be determined with reasonable accuracy, assuming that the amount of fat and the specific gravity be known. If F represents the percentage of fat, T the total solids, and G the figures of the specific gravity beyond the first decimal place, the formula may be expressed: (1) $F = 0.859\ T - 0.2186\ G$; or, (2) $T = \frac{0.2186\ G + F}{0.859}$. This same formula may be used to determine the percentage of fat if the specific gravity and total solids are known by substituting their equivalent values and working out the equation.

Determination of Mineral Matter.—The residue obtained in the determination of total solids is ignited and kept at a low red heat until the ash is perfectly white. The dish is then cooled in a desiccator and again weighed. The difference between this final weight and the original weight of the empty dish represents the amount of mineral matter in the amount of milk taken.

Determination of Fat.—There are many methods for the determination of the fat of milk. The most rapid process and at the same time one which will give sufficiently accurate results for nearly all practical purposes, is known as the *Babcock Centrifugal Method.* This process is in common use at experimental stations throughout the country. It is comparatively simple in technique and can be applied to several specimens at the same time, and is the method which will be found most useful in the majority of cases.

(1) Babcock Centrifugal Method. The method is briefly as follows: With a special pipette, 17.6 c.c. of milk are measured out and mixed with an equal quantity of strong sulphuric acid (the specific gravity of which must be within 1.800 and 1.820) in a flask of special construction. This flask has a small base, with a capacity of about 40 c.c., and an elongated neck with a capacity of about 2 c.c., and is so graduated that each division represents 0.5 per cent. of fat. The flask with its equal volumes of milk and acid is placed in an especially designed centrifugal machine and whirled for five minutes. The casein is completely dissolved forming a dark-brown fluid, and the calcium salts are precipitated out as insoluble sulphates. The heat of the reaction is sufficient to melt the fats and keep them in a molten condition. Hot water is then added up to the beginning of the graduated scale on the neck and the centrifugal machine is again whirled for two minutes, at the expiration of which more hot water is added in sufficient quantities to bring the layer of fat which has separated well up into the neck. The flask is whirled for a third time for one minute and then the reading is taken. The depth of the fat layer in reference to the scale determines the percentage of fat in the sample of milk taken. In taking the readings the extreme points of the menisci at the top and at the bottom are to be considered the terminals of the fat column.

The employment of an acid of greater specific gravity than 1.820 makes it impossible to obtain a clear layer of fat, owing to the carbonizing action of the acid upon the lactose. On the other hand, if the specific gravity is below 1.800, the casein will not be entirely dissolved and part of the unchanged curd will appear on the surface. A certain amount of practice is necessary to obtain even approximately accurate results by this method. The small hand machines suffice for ordinary work, but to obtain the most accurate results the more elaborate and expensive machines are necessary, and one must appreciate the many sources of error and the proper way of avoiding

them. For these details the reader is referred to the larger treatises on milk analysis.

For determining the percentage of fat in skimmed milk and in creams, special forms of flasks are used.

The Lactoscope. The lactoscope is an instrument invented by Feser, the principle of which is based on the fact that the opacity of milk is due mainly to the fat globules in suspension, and that the greater the dilution needed to reduce the opacity so as to allow the passage of light, the greater must be the fat percentage of the milk. The lactoscope consists of a wide glass tube containing in the constricted lower end a milk-glass cylinder, the wall of which is just 4.75 mm. from the surrounding tube. The larger cylinder has a double scale showing the number of cubic centimetres of water used in the dilution, and on a corresponding level the percentage of fat indicated by the dilution. The smaller cylinder, which is inserted into the constricted portion of the larger cylinder, is marked at regular intervals by several equally heavy black lines.

In using the lactoscope to determine the percentage of fat present in a sample of milk 4 c.c. of the specimen are placed in the instrument through the opening at the top of the larger cylinder. Water is then added, little by little, until the opacity of the mixture has been so reduced that the black glazed lines on the smaller white cylinder can be discerned so distinctly that they can be counted. The height of the liquid on the scale is then noted and the fat percentage indicated.

This method, while yielding fairly satisfactory results, depends so much on the individual equation of the observer and on the outside conditions, such as the intensity of the light, that it is not to be relied upon for very accurate quantitative work.

The Paper-Coil Extraction Method. For the most accurate determination of fat, use is made of a Soxhlet extraction apparatus. The apparatus consists of three pieces which fit together by ground glass joints. The top piece is an upright Liebig condenser, the coil of which opens into the main cylinder of the second piece. This second or middle piece, in which the extraction process occurs, consists of a large tube sealed at the bottom, from which a narrower cylinder with an open end projects downward connecting with the third piece, which is a simple flask. The two cylinders of the middle piece are connected by a side tube which opens into the upper portion of each, and also by a siphon which opens from the side of the bottom of the large cylinder, extends upward parallel to the main cylinder, then turns downward, piercing the middle of the wall of the lower cylinder and terminates within and just below its lower end.

The method of extraction is as follows: A strip of filter paper, free from substances soluble in ether and alcohol, and made into a coil is dipped into a beaker containing a definite amount of milk, carefully weighed, and kept there until nearly the whole amount has been absorbed. The beaker is then weighed and the loss in weight represents exactly the weight of the milk absorbed by the filter paper. The coil is then dried in an air-bath at 100° C. for one or two hours, and is then inserted into the extractor of the Soxhlet apparatus, a piece of absorbent cotton having previously been placed in the bottom to prevent the entrance of solid particles into the siphon tube. If desired, the coil may be placed in a cartridge of thick filter paper which fits within the cylinder. The flask constituting the third and lower part of the apparatus is then carefully weighed and filled with ether or whatever extracting agent is used, and the three parts of the apparatus are then connected. The flask containing the ether is heated over a water-bath, causing the ether to volatilize, and the vapor which passes upward through the side tube into the extracting chamber and thence to the condenser is re-condensed into liquid form and drops from the condensing coil into the extracting tube and upon the milk, the fat of which is to be extracted. This process continues until the condensed liquid has attained a sufficient height to cause the siphon to act, at which moment the ether with its extracted fat is siphoned downward into the flask from which the ether was originally volatilized. The volatilization continues, and the extracting chamber is filled and emptied as often as is necessary, the non-volatile fat remaining in the flask and the vaporized ether repeating its mission until all the fat in the milk within the extracting chamber has been transferred to the flask. When the process has been repeated about twelve times the flask is detached, the ether is vaporized off, the flask is cooled and again weighed, and the increase in the weight represents the weight of the fat extracted from the known weight of milk, from which the percentage of fat is easily calculated; that is, the weight of the milk absorbed by the paper coil is to the increase in the weight of the flask as 100 is to x.

Example: The difference in weight of the beaker containing the milk before and after the insertion of the paper coil was 4.98 gm.; the increase in the weight of the flask after distillation of the ether was 0.180 gm.; therefore $4.98 : 0.180 :: 100 : x$. $x = 3.61$ — the fat percentage in the milk.

The Werner-Schmidt Method. Another method for the accurate determination of fat in milk is known as the Werner-Schmidt method. For this process 10 c.c. of milk and an equal volume of hydrochloric acid are boiled in a test tube or heated in a steam-bath until a dark-brown color is produced. The mixture is then cooled and shaken with 30 c.c. of ether, and after standing the supernatant ether is withdrawn by means of a pipette. This procedure is repeated several times with small amounts of ether. All the ether thus obtained is collected in a weighed flask. The ether is then distilled off leaving a residuum of fat which is heated to constant weight, cooled, and weighed again. The gain in weight of the flask equals the weight of the fat extracted from the 10 c.c. of milk. The process may be simplified by placing the milk and acid in a graduated test tube and shaking with ether. An aliquot part of the ether solution may then be withdrawn with a pipette and evaporated to dryness and weighed. The weight of fat in the whole amount of ether can then easily be computed. Correction must be made for the specific gravity of the milk.

Example: If 10 c.c. of milk of 1.030 specific gravity is used, the weight of the milk is 10.30 gm. If the weight of fat left after distilling off the ether is 0.385 gm., which represents the amount of fat in the 10 c.c. of milk originally used, the percentage of fat present is easily determined by making the proportion $10.30 : 0.385 :: 100 . x$. $x = 3.73$ — the percentage of fat in the milk.

The Babcock Asbestos Method. In this process, the milk is treated in the same manner as described above for the estimation of total solids, and the fat in the residue thus obtained is extracted in a Soxhlet extraction apparatus, the technique and computation being the same as in the paper-coil extraction method described above.

Determination of Milk Sugar or Lactose.—The determination of the amount of lactose in milk may be made by titration with Fehling's solution, by polariscopy, or by gravimetric analysis by the Soxhlet-Alliha method.

A. Titration with Fehling's Solution. The general principle of this method is the same as that which underlies the estimation of glucose in the urine. Details as to composition of the solutions and the technique of the test will be found under *Urine.* The especial points in reference to milk analysis may be briefly stated. Twenty-five cubic centimetres of milk carefully measured in a 25 c.c. pipette are placed in an evaporating dish and diluted four times with water, and then heated to 40° C. The casein is then precipitated by addition, drop by drop, of acetic acid, stirring constantly until the curds and clear whey have separated. The whole amount is then transferred to a graduated 500 c.c. flask and diluted with water up to the 500 c.c. mark, and a portion filtered, the filtrate being used for the titration. Ten cubic centimetres each of the Fehling's solutions A and B are carefully measured out with a 10 c.c. pipette and mixed in a flask, and brought to the boiling point. To this solution the sugar solution is added from a burette which is

graduated in tenths of a cubic centimetre, until the blue color of the copper solution is entirely discharged, the same precautions being observed as in the test for glucose in the urine. The calculation of the sugar percentage is then easily made. If 30 c.c. of the *diluted* whey, that is the solution containing the lactose, are required to reduce the 10 c.c. of copper sulphate used in solution A, the amount of *undiluted* whey which would be required would be 1.5 c.c. (25 c.c. of the milk having been diluted to 500 c.c.). We know that 10 c.c. of solution A will be reduced by exactly 0.067 gm. of lactose. Therefore 1.5 c.c. of undiluted whey contains 0.067 gm. of lactose. The percentage of lactose, therefore, may be expressed in the proportion $1.5 : 0.067 :: 100 : x$. $x = 4.46$, the percentage of lactose in the milk.

When greater degrees of accuracy are desired, Soxhlet's and Allihn's gravimetric method, or some modification of it, should be used. A good description of the technique of the process will be found in Sommerfeld's book.[2]

B. Determination of Lactose by Polariscopy. This method is rapid and accurate. The description of the principles involved in the use of the polariscope will be found elsewhere. The method in its especial application to milk analysis is briefly as follows: Into a flask graduated to contain 102.6 c.c. (if the instrument used is one in which the sucrose normal weight is 26.048 gm.) is weighed 65.95 gm. of milk and 1 c.c. of a solution of mercuric nitrate of pharmacopœial strength is added. The solutions are thoroughly mixed and diluted up to the 102.6 c.c. mark. If the instrument used is one, the sucrose normal weight of which is 16.19 gm., 40.99 gm. of milk are taken and the dilution is made up to a 101.6 c.c. mrk. The contents of the flask are then filtered through dry filter paper, and the 200 mm. observation tube is filled with the filtrate. The reading on the scale when the field of observation is uniform, when divided by two, gives the percentage by weight of lactose.

Determination of Total Proteids.—When total proteids alone are to be estimated, irrespective of the relative proportions of the caseinogen, lactalbumin, and lactoglobulin, we may resort directly to the Kjeldahl process or approximately accurate results may be obtained by taking the difference between the total solids and the sum of the other solids.

A. Kjeldahl Method. Five grams of milk, 20 c.c. of sulphuric acid of 1.840 specific gravity (free from nitrates and ammonium sulphate) and 0.7 gm. of mercuric oxide are introduced into a Kjeldahl flask and gently heated in an inclined position and just below the boiling point of the acid, until froth ceases to form. The mixture is then boiled until it is clear and of a pale straw color. The heat is then withdrawn and sufficient potassium permanganate is added in small quantities to turn the fluid a permanent green or purple color. The mixture is then cooled and transferred into a large distilling flask with the capacity of at least half a litre, care being taken to rinse out the Kjeldahl flask thoroughly with distilled water, or a few fragments of pumice stone. About half a gram of zinc dust is added to prevent bumping, and also 25 c.c. of a four-per-cent. aqueous solution of sulphide of potassium to prevent the formation of compounds of ammonium and mercury which are not completely decomposed by alkalies.

Then add to the distilling flask with its contents enough of a saturated solution of sodium hydrate to make the reaction strongly alkaline.

The sodium hydrate should be added slowly to avoid the generation of too much heat, which may cause more or less of the ammonia to be volatilized and lost, thus giving rise to a considerable source of error. It is often desirable to immerse the distilling flask in ice water prior to the addition of sodium hydrate, so as to keep down the temperature of the mixture. The flask is next connected with a Liebig condenser, to the further end of which is attached a glass tube bent at right angles so as to reach to the bottom of a flask into which the ammonia is to be distilled. Into this flask is measured 50 c.c. of a decinormal solution of sulphuric acid. The distilling flask is then heated until about 175 c.c. of fluid has been distilled, when it is fair to assume that all the ammonia has been carried over into the flask containing the decinormal sulphuric acid. Eight or ten drops of methyl orange is then added as an indicator, and the degree to which the sulphuric acid has been neutralized by the ammonia is estimated by titrating with a decinormal solution of sodium hydrate. From this difference in strength of the acidity the amount of ammonia is calculated, and from this the amount of nitrogen. The amount of nitrogen multiplied by 6.25 (the factor for milk) gives the total proteid. The result includes the small percentage of nitrogenous extractives.

B. Method of Ritthausen. This method depends upon the precipitation of the total proteids by means of copper sulphate and sodium hydroxide. The proteids of colostrum milk are only partially precipitated by this process, and it is therefore not always applicable. An objection to this method, and also to other methods involving the precipitation of proteids, is the possibility that the extractives may be carried down at the same time.[3] Munk's modification or Ritthausen's method may be employed.[4]

C. Total Proteids by Difference. If the percentage of total solids is known, the total proteids may be estimated by subtracting the sum of the percentages of fat, sugar, and mineral matter, from the percentage of total solids. It is obvious, however, that any error in the estimation of the fats or sugar or mineral matter, will by this method give rise to an inaccuracy in the percentage of proteids.

Determination of Casein and Albumins Separately.—The importance of the difference between proportions of caseinogen and lactalbumin in human milk and cow's milk has recently been emphasized in connection with the use of whey-cream mixtures in infant feeding.[5, 6, 7, 8] Methods for the quantitative determination of these differences in proportions do not attempt to eliminate the possible source of error due to nitrogenous extractives.

By precipitation with magnesium sulphate.[9] The method suggested by Leffmann and Beam is as follows: Twenty cubic centimetres are mixed with a saturated solution of $MgSO_4$ and the powdered salt is added to saturation. The mixture is washed in a graduated measure with a small amount of the saturated solution of $MgSO_4$, the volume noted, and the whole allowed to stand until separation takes place. The liquid is then filtered, as much as possible of the clear portion being first drawn off with a pipette and passed through the filter. An aliquot portion of the filtrate is taken, the albumin precipitated by a solution of tannin, acid, and the nitrogen in the precipitate determined by the Kjeldahl process. From this the percentage of lactalbumin may be estimated, and the caseinogen determined by subtracting the percentage of lactalbumin from that of the total proteids. A slight source of error will exist due to the fact that the traces of lactoglobulin will be precipitated by the magnesium sulphate, and will therefore be included in the percentage of caseinogen.

Products of Milk.—*Butter.*—Butter, the most valuable product of milk, is made by the churning of milk or cream by which process the fat globules coalesce and form a mass containing the same ingredients as milk, but with very different proportions. The liquid portion which remains as a by-product is called buttermilk, and is used to some extent as an article of diet. The composition of butter varies greatly according to the character of the milk used and the methods of preparation. Harrington gives the following as a fair average analysis of butter. The analysis of buttermilk is taken from König:

	Butter. Per cent.	Buttermilk. Per cent.
Fat	84.00	1.09
Water	12.00	90.12
Proteids	1.00	4.03
Mineral matter	2.50	.72
Lactose	.50	4.04

Cheese and Whey.—Cheese is prepared by the action of the rennin ferment on milk, by which process the caseinogen is coagulated, carrying down with it the fat and traces of sugar, lactalbumin, and mineral matter.

The fluid portion which remains after the separation of the cheese or curd is the whey. The latter is used as food in very difficult cases of digestion, in infant feeding.[6]

There are a great many varieties of cheese, of varying composition. They may be made from skim milk or whole milk; from cow's milk, goat's milk, or ewe's milk. Richmond classifies cheeses into two classes:

I. Soft Cheeses: These are made by coagulating the caseinogen at a low temperature (below 30° C. or 86° F.). Gervais, Brie, Camembert, Pont l'Evêque, Neufchâtel, and Stracchino cheeses are representatives of this class.

II. Hard Cheeses: These are made by the coagulation of the caseinogen at higher temperatures (30° C. to 95° F.). There are several different types of this class:

(*a*) Cheeses made from milk and cream, such as Stilton.

(*b*) Cheeses made from whole milk, such as Cheddar, Cheshire, Dunlop, Edam, and Gorgonzola.

(*c*) Cheeses made from partially skimmed milk, as Parmesan, Derby, Gruyère.

Roquefort cheese is prepared from sheep's milk.

There is still another variety of cheese, not made by rennet, but prepared by warming the milk and allowing the caseinogen to be precipitated by the process of souring. The "ripening" process of cheese is essentially a decomposition process carried on by different kinds of bacteria and moulds. The different flavors are largely due to products of their growth.

The nutritive value of cheese is very great. With the exception of the cheeses made from skimmed milk, cheese may be considered to be approximately one-third fat and one-third proteid. The subject is hardly of sufficient importance to the physician to warrant us in taking the space which would be required for detailed analysis of the different varieties.

The analysis of whey as given by König is: water 93.38 per cent., fat 0.32 per cent., proteids 0.86 per cent., milk sugar 4.79 per cent., mineral matter 0.65 per cent. A somewhat higher percentage of proteids is found in analyses of whey in the country. According to the investigations of the United States Department of Agriculture (Bulletin 28) whey contains one per cent. of proteids, estimated as total nitrogen. White and Ladd found almost identically the same percentage. Monti also found that the proteids vary from 0.83 to one per cent. The percentage of fat present varies according to the method of making the whey. If old milk or skimmed milk is used, larger percentages are found than if the whey is made from fat-free milk—that is, from milk from which the fat has been almost completely removed by means of a centrifugal separator. In the latter case, only traces of fat are present so small in amount that they may be disregarded in calculating percentage modifications. The economy of using fat-free milk in obtaining whey is self-evident.

Lactose or Milk Sugar.—Lactose or milk sugar is prepared commercially by evaporating whey *in vacuo*, after the lime has been neutralized by means of acids, and the solution clarified by alum or by other means; it has the composition of a galactose-glucoside and undergoes hydrolytic cleavage by acids yielding a mixture of galactose and glucose. The most common form is the hydrated milk sugar obtained by crystallization from water. Its water of hydration is given off at 130° C., and, as stated above, it is converted into a lacto-caramel at 170° C. and melts at 213.5° C. It exhibits multi-rotation. Its rotatory power is diminished after contact with water for twenty-four hours or more.

Milk sugar has the property of reducing alkaline solutions of salts of the heavy metals, and on this property is based Fehling's test for sugar. Ten cubic centimetres of Fehling's copper solution correspond to 0.06769 gm. of lactose, whereas in cane sugar it is 0.059 gm., and in glucose 0.05 gm. The lactose of cow's milk undergoes fermentation only with the enzyme lactose. The lactose of mare's milk, on the other hand, readily undergoes alcoholic fermentation, indicating a difference in the chemical nature of the two sugars. It is also possible that the lactose of human milk and that of cow's milk differ chemically. Milk sugar is not so readily soluble in water as cane sugar. In the modification of milk, by sugar solutions, twenty-per-cent. solution represents the practical maximum degree of concentration that can be used.

Condensed Milk.—Condensed milk, or "evaporated" milk, is prepared commercially by evaporation of milk to about one-third or one-fourth of its volume. It may be made from whole milk and be rich in fat, or from skimmed milk, the usual source, and be very deficient in fats. To prevent decomposition, cane sugar is usually added in large proportions; about one and one-quarter pounds to each gallon of milk (Richmond). Glucose is sometimes used in place of cane sugar. Condensed milk, sweetened, will keep for a long time without appreciable change.

The composition of European samples of condensed milk as given by König is as follows:

	Condensed milk not sweetened.	Condensed milk sweetened.
Fat	12.42 per cent.	10.35 per cent.
Sugar	14.49 "	50.06 "
Proteids	11.92 "	11.79 "
Ash	2.13 "	2.19 "
Water	58.99 "	25.61 "

Holt gives the following results of the analysis of one of the most extensively advertised condensed milks in this country, showing also the results obtained by diluting according to direction for purposes of infant feeding:

	Condensed Milk.	With six parts of water added.	With twelve parts of water added.	With eighteen parts of water added.
Fats	6.94	0.99	0.53	0.36
Proteids	8.43	1.20	.65	.44
Sugar (cane, 40.44; milk, 10.25)	50.69	7.23	3.90	2.67
Salts	1.39	.17	.10	.07
Water	31.30	90.49	94.82	96.46

It will be seen by the table that condensed milk diluted for use is decidedly deficient in fats, and in the larger dilutions in sugar and proteids. The insufficiency of such a food as a substitute for mother's milk is apparent. This aspect of the question is more fully discussed in the article on *Infants, Artificial Feeding of.*

Milk Powder.—Milk powder is prepared by the evaporation of milk *in vacuo* to dryness. Two analyses of specimens are given by Richmond:

	Per cent.	Per cent.
Fat	15.2	13.5
Milk sugar	21.7	21.3
Cane sugar	42.5	40.9
Proteids	15.1	14.9
Ash	3.3	3.2

Peptonized Milk.—Peptonized milk is prepared by submitting milk to the action of the trypsin ferment, the active proteolytic enzyme of pancreatic juice. Bicarbonate of soda is added as the trypsin is active only in an alkaline medium. The trypsin is obtained from the pancreas of the pig. The preparation is known commercially as "Extractum Pancreatis." The process usually employed is that recommended by Fairchild.

One pint of fresh cow's milk and four ounces of water and five grains of extractum pancreatis and fifteen grains of sodium bicarbonate are added. The mixture is raised to a temperature of 105° F. and is not allowed to go above 115° F. for fear of destroying the enzyme, thereby checking the process. The bottle is shaken from time to time.

In partial peptonization the process is carried on for from five to twenty minutes, according to the degree of peptonization required. The temperature is then allowed to rise to a degree sufficient to kill the enzyme,—140°–150° F. is quite enough. The action of the enzyme may be checked but not destroyed by placing the bottle at once upon the ice. If complete conversion of the proteids to peptones is desired, the process must be continued for two hours. The taste of the milk is altered by the process, becoming bitter and unpalatable; but this change does not occur in the shorter intervals of five or ten minutes. The object of the process is to reduce the proteids to a non-coagulable form capable of easy or direct absorption, either when administered by mouth or by rectum as nutrient enemata. Peptonizing powder is now dispensed in convenient tubes or tablets ready for use.

Vieth gives the following analyses of undiluted peptonized milk:

	Per cent.		Per cent.
Water	89.20	Albumin	0.07
Fat	3.41	Albumose	1.88
Sugar	3.80	Mineral matter	.68
Casein	.96		

Koumyss.—Koumyss was originally made by the Tartars by the addition, to mare's milk, of a ferment derived from kephir grains. Both alcoholic and lactic-acid fermentation took place. The mare's milk was placed in leathern vessels, with portions of the previous brewing and the yeast from the kephir grains, and kept at a temperature of from 30° to 40° C.; it was shaken occasionally until the process was completed. It was formerly made of skimmed milk. The process of to-day has been considerably changed. Many manufacturers use whole milk or milk to which cream, cane sugar, and some water are added. Ordinary yeast is used for the ferment and cow's milk is employed in preference to mare's milk. Holt gives the following formula for the domestic manufacture of koumyss:

One quart of fresh milk, half an ounce of sugar, two ounces of water, and a fresh piece of yeast cake half an inch square, are put in wired bottles and kept at a temperature between 60° and 70° F. for one week; the bottles are shaken five or six times a day. They are then put upon the ice and kept ready for use.

The following analyses by König show the composition of koumyss under the different conditions under which it may be made:

	Mare's milk.	Cow's milk.	Skimmed milk.
Fats	1.46	1.33	0.88
Proteids	2.24	2.66	2.89
Sugar	1.47	4.09	3.95
Alcohol	1.91	1.14	1.38
Lactic acid	.91	.55	.82
Salts	.42	.43	.53
Water	91.29	89.30	89.55

The term "kephir" or "kefir" was formerly used for the product obtained by the action of kefir grains on cow's milk.

Matzoon.—Matzoon or mazoum is a thick, partly coagulated fluid, resembling cream which has soured. It is made by the action of a ferment imported from Armenia upon cow's milk. On warming, it settles into a liquid whey and an insoluble curd. The milk is first boiled and then allowed to ferment with the matzoon ferment in an open vessel kept at 105° F. The process is carried for twelve hours, the temperature being gradually lowered to 70° F., after which it is put upon the ice. It will keep under proper conditions for two or three weeks. It is used in cases of the same kind as those for which koumyss is prescribed.

The composition of matzoon as given by Dadirrian is as follows:

	Per cent.		Per cent.
Proteids	3.48	Alcohol and other products of fermentation	0.13
Fat	3.49	Mineral matter	.69
Milk sugar	3.68	Water	87.63
Lactic acid	.90		

Percentage Modification of Cow's Milk.—The idea of modification of milk according to definite percentages of fats, sugar, and proteids in order to adapt it to the varying requirements of infant feeding has very appropriately been called the American system of infant feeding. It was in this country that it really had its inception, and its development and practical application have been under the fostering care of a few eminent and far-sighted American physicians, chief of whom is Dr. Thomas Morgan Rotch, of Boston, whose name has been associated with the idea more closely than that of any other American physician.

The essential principle underlying this system is the now generally accepted fact that it is not intolerance for milk as a whole which causes so much disturbance in infants, but an incapacity of the individual child to digest certain ingredients of milk. In other words, there is a variable ability of the infant to digest fats, sugars, and proteids, giving rise to what may be spoken of as fat indigestion, sugar indigestion, and proteid indigestion. In one child it may be the fat which causes the trouble; in another, the sugar; in still another, the proteid material; while in a fourth, all three elements may be at fault. Obviously, therefore, the ideal system must provide for percentages of fat, sugar, and proteids in any desired combination. The Meigs milk formula devised by Arthur V. Meigs in 1882 recognized in a limited way the importance of definite percentage combinations. He started on the basis of the results of forty-three analyses of human milk and found the composition to be approximately, fat four per cent., sugar seven per cent., and proteids one per cent. Then he worked out the formula by which, by the use of creams, milk, milk sugar, lime water, and water, he was able to duplicate the composition of human milk. This formula corresponded closely to one which the elder Meigs had used and recommended in a long and successful practice among infants.

The formula of Meigs assumed that mother's milk was of constant quality and that, therefore, a mixture made to correspond to it in its percentage composition would satisfy the demands of infant feeding. We know now, however, that human milk is of very variable quality, and in practice we also find that infants require very different percentage combinations, according to their age, development, state of health, and many other conditions.

The scope of our subject limits us to the theory of percentage modification of milk and the practical methods of obtaining the different combinations of fat, sugar, and proteids. The practical application of these modifications to the subject of infant feeding is treated in its appropriate place.

The earlier methods of the simple dilution of whole milk with varying parts of water has, as its principle, the reduction of the proteids to a proportion similar to that which occurs in human milk. The dilution, however, affects the fats and sugars as well; and the general effect in comparison with human milk is seen in the following table:

	Fats.	Sugar.	Proteids.
Cow's milk	4.0	4.50	3.50
Cow's milk diluted 1 to 2	1.33	1.50	1.16
Human milk	4.00	7.00	1.50

Obviously, simple dilutions of whole milk with water or any other diluent, cannot suffice to produce a milk resembling mother's milk.

The next step in advance was the dilution of creams with water and the addition of milk sugar to make up the deficiency of that constituent. The results obtained by this method may be illustrated as follows:

	Fats.	Sugar.	Proteids.
Cream	12	4.30	3.30
Cream diluted 1 to 2	4	1.43	1.10

In this way fats and proteids are easily obtained, and the amount of sugar can be raised to any desired percentage by the addition of dry milk sugar, or of sugar solutions of varying strength in place of the water.

The question here presents itself, What are the limitations to the combinations which are possible under the employment of this method of diluting creams? As the composition of cream varies according to the percentages of fat, we must agree on a fixed standard for the composition of the materials used. It is fully appreciated that the figures given below do not accurately represent the analyses of all varieties of cow's milk, and that therefore in any given case there is always a possible error; but unless milk is analyzed daily, which is impracticable, we have no alternative but to adopt an average standard and let that be the basis on which we make our calculations. The average analysis, therefore, which we shall use, unless otherwise stated, is that which has been given above, but which for convenience may be tabulated as follows:

	Fats.	Sugar.	Proteids.
Fat-free milk	Trace.	4.60	3.60
Whey	Trace.	4.79	1.00
Whole milk	4	4.50	3.50
Eight per cent. cream	8	4.40	3.40
Ten per cent. cream	10	4.30	3.35
Twelve per cent. cream	12	4.20	3.30
Sixteen per cent. cream	16	4.05	3.20
Twenty per cent. cream	20	3.90	3.10

The traces of fat in the fat-free milk obtained by using the lowest eight ounces of a quart jar of milk after setting eight hours, or by means of a centrifugal machine properly regulated, and the traces of fat in whey made from fat-free or skim milk, as shown by numerous analyses at the Walker-Gordon Laboratory, rarely exceed 0.05 per cent., and can therefore be excluded in our calculations.

The following table, therefore, shows the lowest possible proteids which may be obtained with fat percentages in our mixtures of from 1 to 4, in which creams of from 8 to 20 per cent. fat are used:

Eight-per cent. cream gives with

Fat one per cent. lowest possible proteids of 0.47
" two " " " " " .... .85
" three " " " " " 1.27
" four " " " " " 1.70

Ten-per-cent. cream gives with

Fat one per cent. lowest possible proteids of 0.38
" two " " " " " .... .67
" three " " " " " 1.00
" four " " " " " 1.34

Twelve-per-cent. cream gives with

Fat one per cent. lowest possible proteids of 0.27
" two " " " " " .... .54
" three " " " " " .... .82
" four " " " " " 1.08

Sixteen-per-cent. cream gives with

Fat one per cent. lowest possible proteids of 0.20
" two " " " " " .... .40
" three " " " " " .... .60
" four " " " " " .... .80

Twenty-per-cent. cream gives with

Fat one per cent. lowest possible proteids of 0.15
" two " " " " " .... .31
" three " " " " " .... .46
" four " " " " " .... .62

It is obvious from the above table that in simple dilutions of cream we are limited in our proteid percentages. To get low proteids with high fat percentages in our mixtures, we must use concentrated creams. To get high proteids with creams of any strength, with the exception of eight-per-cent. cream, we must add whole milk or fat-free milk to supplement the deficiency of proteids obtained from the diluted creams.

Much credit is due to Thompson S. Westcott, of Philadelphia, for his elaborate monograph on the scientific modification of milk which was published in *International Clinics*, October, 1900. Taking the previous formulæ of Taylor and those of Baner, he has worked out mathematical formulæ which are of universal application, and has established the principles of modification on a truly scientific basis.

These formulæ may be briefly expressed as follows. For detail the reader is referred to the original monograph.

F = prescribed percentage of fat.
S = prescribed percentage of sugar.
P = prescribed percentage of proteids.
C = total quantity of cream in ounces.
M = total quantity of milk in ounces.
W = total quantity of water in ounces.
L = total quantity of dry milk-sugar in ounces.
Q = total quantity of mixture.
a = known percentage of fat in cream.
a′ = known percentage of fat in milk.
b = known percentage of proteids in cream.
b′ = known percentage of proteids in milk.
c = known percentage of sugar in cream.
c′ = known percentage of sugar in milk.

Since the actual quantity of proteids in a percentage mixture is the sum of the quantities of proteids contributed by the milk and cream; and again, since the actual quantity of fat is the sum of the quantities of fat contributed by the milk and the cream, the following fundamental formulæ may be stated: (1) $Q \times P = b'M + bC$; (2) $Q \times F = a'M + aC$.

By transposing, we may get value for M in equation (1), giving $M = \frac{QP - bC}{b'}$.

If this value of M is substituted in equation (2), we have, by transposition and collecting, an equation which will give us the quantity of cream to be used in any combination; *i.e.*, (3) $C = \frac{(Q\, b' F - a' P)}{ab' - a' b}$.

In the same way by finding a value for M in equation (2) instead of (1) we have (4) $M = \frac{QF - aC}{a'}$.

The amount of sugar in a given mixture is that contributed by the cream, by the milk, and the dry sugar added. This may be expressed in the following formula: $\frac{Q \times S}{100} = \frac{c'M}{100} + \frac{cC}{100} + L$.

By transposition, we obtain the value of L, viz., (5) $L = \frac{QS - c'M + cC}{100}$.

The amount of water to be added is calculated by the following formula: (6) $W = Q - (C + M)$.

Formulæ (3), (4), (5), and (6) therefore represent the formulæ necessary for obtaining the quantities of cream, milk, sugar, and water called for in any combination. They are of universal application, the values for the different letters varying according to the strength of the creams and milk used.

Example. Let us suppose that we wish to calculate for twenty ounces of 4 per cent. fat, 7 per cent sugar, and 1.50 per cent. proteids, using 16 per cent. cream and whole milk.

Sixteen per cent. cream =	Fat = a 16	Proteids = b 3.20	Sugar = c. 4.05
Whole milk =	Fat = a′ 4	Proteids = b′ 3.50	Sugar = c′. 4.50

By substituting these values in formulæ (3), (4), (5), and (6), we obtain the following result:

(3) Cream $(C) = \frac{20\,(3.50 \times 4 - 4 \times 1.50)}{16 \times 3.50 - 4 \times 3.20} = \frac{160}{44} = 3.63$ ounces.

(4) Milk $(M) = \frac{(20 \times 4) - (16 \times 3.63)}{4} = \frac{21.92}{4} = 5.48$ ounces.

(5) Sugar $(L) = \frac{20 \times 7 - (4.50 \times 5.48 + 4.05 \times 3.63)}{100}$ $= \frac{100.64}{100} = 1$ ounce.

(6) Water $(W) = 20 - (3.63 + 5.48) = 10.89$ ounces.

If we so contrive as to obtain all our fat from the

cream and use fat-free milk in place of whole milk to obtain a greater percentage of proteids than that contributed by the cream, we simplify our formulæ and the work of computation, for we can substitute 0 for the fat value (a') of the milk in formulæ (3), (4), and (5), and we get the following:

Formula (3) becomes: Cream $(C) = \frac{QF}{a}$.

Formula (4) becomes: Fat-free milk $(M) = \frac{QP - bC}{b'}$.

Formula (5) becomes: Sugar $(L) = \frac{QS - 4.50\,(M + C)}{100}$.

The formula for the amount of water to be added remains the same, *i.e.*: Water $(W) = Q - (C + M)$.

Westcott has also prepared formulæ by which one may calculate combinations of fats and sugars with different proportions of caseinogen and lactalbumin.[8]

For purposes of convenience in the management of large clinics and also for teaching, the writer has prepared the following table, by which practically all the percentage combinations which a physician is likely to use in practice can be more easily and quickly calculated than by means of formulæ, which to some minds are complicated and difficult to understand. It is so arranged that the physician may exercise a choice in the percentage of creams to be used, and can see at a glance what combinations are impossible with creams of different strength. The calculations are made for twenty-ounce mixtures; for each additional five ounces it is only necessary to multiply each ingredient by one-quarter, and add it to the amount of twenty ounces. The percentage of lime water may be increased at will by remembering that each additional ounce in a twenty-ounce mixture increases the alkalinity five per cent., and the amount of lime water added beyond what is given in the table, must be subtracted from the amount of water used as a diluent. For accuracy the milk sugar should be dissolved in a portion of water and then water added up to the amount called for. The amount of sugar required is expressed in measures. The measure is a small tin dipper obtained at any milk laboratory. It holds just three and three-eighths drachms.

Whey Cream Mixtures.—Whey cream mixtures may be obtained by using whey as a diluent, in place of the boiled water, preferably in the combinations containing low proteid percentages. Each two ounces of whey replacing an equal quantity of water in a twenty-ounce mixture will raise the whey proteid percentage 0.10, and will increase the sugar percentage 0.50. The total sugar percentage is, therefore, the amount contributed by the cream and fat-free milk, which is indicated in the last column of the table above—plus that of the whey. The amount of dry sugar which must be added to make the desired final sugar percentage can be easily calculated by reference to the following table:

	Per cent. of sugar.
One measure of dry lactose in a 20-ounce mixture gives..	2.00
One-half measure of dry lactose in a 20-ounce mixture gives..........	1.00
One-quarter measure of dry lactose in a 20-ounce mixture gives..........	.50

(One measure is approximately one level tablespoonful.)

Example.—If in formula 21 fourteen ounces of whey are added in place of the same quantity of water, the whey proteids are increased 0.70 per cent., making total proteids of 1.30 per cent. The sugar contributed by the cream is 0.78; that by the whey 3.50—making a total of 4.28. The desired percentage of sugar is 6, therefore the balance of 1.72 per cent. may be obtained by adding a little short of one measure of sugar.

Whey should be made of fat-free milk, and should be heated to 150° F. (65° C.) before it is added to the cream mixture, to destroy the rennin enzyme. One quart of fat-free milk will yield about twenty-four ounces of whey.

The conditions under which the different percentages of creams may be obtained are given above on page 831.

Milk Laboratories.—The first laboratory in the world for the exact modification of milk was established in Boston in 1891, under the name of the Walker-Gordon Laboratory. Its scientific development has been under the fostering care of Dr. Thomas Morgan Rotch, professor of diseases in children in Harvard University. The ex-

TABLE FOR THE PERCENTAGE MODIFICATION OF COW'S MILK. (LADD.)

Number.	℞ 20-oz. Mixtures Percentage of— Fat.	Sugar.	Proteid.	Alk.	Ounces of Cream. Ten per cent.	Twelve per cent.	Sixteen per cent.	Twenty per cent.	Ounces Fat-free Milk Used with Creams of— Ten per cent.	Twelve per cent.	Sixteen per cent.	Twenty per cent.	Ounces. Lime water.	Boiled water.	Milk sugar measure.	Sugar per cent. without dry sugar.
1	1.50	4.50	0.25	5	*	*	*	1½	*	*	*	0	1	17½	2	0.33
2	1.50	4.50	.50	5	3	2½	2	1½	0	½	1	1½	1	16	2	.61
3	2.00	5.00	.25	5	*	*	*	2	*	*	*	0	1	17	2¼	.75
4	2.00	5.00	.50	5	*	3¼	2½	2	*	*	½	1	1	15¾	2¼	.73
5	2.00	5.00	.75	5	4	3¼	2½	2	¾	1½	2¼	2¾	1	14½	2	1.01
6	2.00	5.50	1.00	5	4	3¼	2½	2	1¾	2½	3¼	3¾	1	13¼	2¼	1.30
7	2.50	5.00	.50	5	*	*	3¼	2½	*	*	0	¾	1	15¾	2¼	.73
8	2.50	5.50	.75	5	*	4¼	3¼	2½	*	¼	1¼	2	1	14½	2¼	1.01
9	2.50	6.00	1.00	5	5	4¼	3¼	2½	1	1¾	2¾	3½	1	13½	2½	1.23
10	3.00	6.00	.50	5	*	*	3¾	3	*	*	0	¾	1	15¼	2½	.84
11	3.00	6.00	.75	5	*	5	3¾	3	*	0	1¼	2	1	14	2½	1.12
12	3.00	6.00	1.00	5	6	5	3¾	3	0	1	2¼	3	1	13	2¼	1.35
13	3.00	6.00	1.25	5	6	5	3¾	3	1¼	2¼	3½	4¼	1	11¾	2¼	1.35
14	3.00	6.50	1.50	5	6	5	3¾	3	2½	3½	4¾	5½	1	10½	2¼	1.91
15	3.00	6.50	2.00	5	6	5	3¾	3	5½	6½	7¾	8½	1	7½	2	2.68
16	3.50	6.00	.50	5	*	*	*	3½	*	*	*	0	1	15½	2½	.78
17	3.50	6.00	.75	5	*	*	4½	3½	*	*	0	1	1	14½	2½	1.01
18	3.50	6.50	1.00	5	*	5¾	4½	3½	*	0	1¼	2¼	1	13¼	2½	1.26
19	3.50	6.50	1.25	5	7	5¾	4½	3½	½	1¾	3	4	1	11½	2½	1.68
20	3.50	6.50	1.50	5	7	5¾	4½	3½	2	3¼	4½	5½	1	10	2¼	2.02
21	4.00	6.00	.60	5	*	*	*	4	*	*	*	*	1	15	2½	.78
22	4.00	6.00	.75	5	*	*	5	4	*	*	0	1	1	14	2½	1.12
23	4.00	7.00	1.00	5	*	*	5	4	*	*	1	2	1	13	2¾	1.35
24	4.00	7.00	1.25	5	*	6¾	5	4	*	¾	2½	3½	1	11½	2½	1.68
25	4.00	7.00	1.50	5	8	6¾	5	4	1	2¼	4	5	1	10	2½	2.02
26	4.00	7.00	2.00	5	8	6¾	5	4	3½	4¾	6½	7½	1	7½	2¼	2.56
27	4.00	7.00	2.50	5	8	6¾	5	4	6¼	7½	9¼	10¼	1	4¾	2	3.20
28	4.00	7.00	3.00	5	8	6¾	5	4	9¼	10½	12¼	13¼	1	1¾	1½	3.88
29	4.00	6.00	3.00	5	8	6¾	5	4	9¼	10½	12¼	13¼	1	1¾	1	3.88
30	4.00	5.50	3.00	5	8	6¾	5	4	9¼	10½	12¼	13¼	1	1¾	¾	3.88

For 25-ounce mixtures multiply the amount of each ingredient by 1¼; for 30-ounce mixtures, by 1½; for 35-ounce mixtures, by 1¾; for 40-ounce mixtures, by 2; for 45-ounce mixtures, by 2¼.

* Combination impossible with strength of cream indicated.

tension of the system and many details in connection with the practical management of the laboratories have been accomplished by the joint efforts of Mr. George E. Gordon, Mr. G. H. Walker, and Mr. J. H. Waterhouse.

Eighteen laboratories have now been established in different parts of this country, in Canada, and in London.

The purpose of the milk laboratory may briefly be stated to be first, to insure a clean, constant, and reliable milk supply, and second, to provide a place where different combinations of milk may be put up according to the prescriptions of physicians, with accuracy and under such conditions of cleanliness and asepsis as to insure the best possible food for infant feeding. Whole milk and creams of guaranteed composition are also provided, with which modification at home may be carried on with the minimum chance of errors in calculations, which in ordinary home modification of milk come from the uncertain quality of the milk purchased, in the great majority of cases, from unknown or unreliable sources.

The milk laboratory is to the physician engaged in the feeding of infants what the apothecary is to the therapeutist. Details as to the nature of the milk laboratories and their use will be found in the article on *Infants, Artificial Feeding of,* and especially in Rotch's "Pediatrics," 1901. *Maynard Ladd.*

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MILK IN RELATION TO PUBLIC HEALTH: MILK-BORNE DISEASES.—In view of the dietetic importance of milk for all classes, but especially for infants, invalids, and the sick and convalescents, it is perfectly natural that much study should have been given to this foodstuff, and that of late years the sanitarian and bacteriologist should have found it a profitable field for research. Indeed, the production of pure milk might well be considered one of the most important problems which confront the sanitarian. Few countries until recently have deemed it necessary to do more than prevent adulteration of the milk, and some of the legislators appear to think that as long as the milk has not been skimmed or watered, and contains the standard of total solids and fats, we need not worry about the germs we eat or drink. This may be a pleasing reflection to persons who do not know that such hydra-headed diseases as scarlet fever, diphtheria, and cholera infantum have been disseminated in the milk supply, that typhoid-fever epidemics have been thus caused, and that milk may be the vehicle of the germs of tuberculosis and other infectious diseases and morbific agents. Space will not permit to do more than briefly point out some of the circumstances under which milk may be the cause of disease.

1. Milk which is Objectionable by Reason of Color, Odor, Taste, and Consistency.—(*a*) *Abnormally Colored Milk.*—Fuchs was the first to point out that *blue milk* may be due to the presence of chromogenic microorganisms, and Neelson and Hueppe proved that this was caused by the bacillus cyanogenes, which may even invade the udder of the cow. Mosler and Uffelmann refer to cases of gastro-intestinal catarrh produced by the consumption of such milk. A uniform blue color is imparted by adulteration with water and certain kinds of cow's feed, and by some drugs. *Yellow milk* may be due to the addition of coloring matter such an annatto or saffron or the development of the bacillus synxanthus (Schrötter), but may also be caused by the ingestion of rhubarb (Mosler). *Red milk* may be caused by rhubarb or by the presence of the bacillus prodigiosus or of the spirillum rubrum, or by the admixture of blood, especially when the milk looks streaky, but it is most often due to giving the animals madder or bedstraw for food. *Brown milk* may be due to the presence of foreign matter or the products of certain fungi. A *bluish-red* color is caused by the bacterium lactis erythrogenes (Hueppe), while *green milk* is generally the result of an excess of fat and incomplete emulsification, sometimes due to the presence of the bacillus fluorescens, and occasionally, as in suppurative affections of the udder, to the presence of green pus.

(*b*) *Abnormal Odor, Taste, and Consistency.*—This may be caused by the character of the food, by exposure of the milk to air charged with foul vapors, or by the presence of foreign matter. The odor of onions is imparted when any of the alia are eaten, and after the ingestion of even a small quantity of skunk cabbage the milk yields the characteristic odor. The consumption of turnips, cabbage, or decaying leaves frequently affects the flavor of the milk. Milk is said to acquire a bitter taste after the ingestion of wormwood or when the animal suffers from disease of the liver, interfering with the proper elimination of the biliary acids and salts; but it is most frequently due to the presence of certain forms of bacteria, generally present in dark, damp, and badly ventilated milk houses; a salty milk often results from cattle grazing upon marshy salt grasses.

Occasionally we see a stringy or filamentous milk which is due to the presence of certain micrococci, very generally found in dirty milk pans or other utensils; sometimes the milk is slimy, and several species of bacteria have been described as the cause of this condition; chief of these organisms is the bacillus lactis viscosus, isolated by Adametz. In rare instances milk presents a soapy taste, which, according to Weigmann, is due to a specific bacillus. It is needless to add that all such milk is unfit for use.

(*c*) *Colostral Milk* and the milk yielded for from ten to fifteen days before calving differ in composition from normal milk; the former frequently contains blood corpuscles from the vaginal passages. Dr. Heisch reports the case of a family using such milk who were attacked with symptoms resembling severe influenza, with high fever and great soreness of the inside of the mouth, throat, and tongue, which were covered with small pustules. The servants, who took the skimmed milk only, remained unaffected. According to Höhne, milk yielded by animals a few days before calving has induced diarrhœa and colic in the consumers. For these reasons it has been deemed best to exclude from sale the milk yielded by animals fifteen days before and five days after parturition.

(*d*) *Milk Sediments.*—Every consumer of milk has doubtless observed the presence of more or less foreign matter at the bottom of the vessel or bottle in which it is kept; indeed, it is a matter of such common occurrence that it hardly excites our attention, and many are disposed to look upon it as a matter of course. Professor Soxhlet, of Munich, was perhaps the first to point out that these deposits are largely made up of excrementitious matter from the cow, which, adhering to the udder of the animal, gained access to the bucket during the act of milking. These sediments are obtained by the centrifuge or by permitting a bottle of milk to stand for two hours; then siphon off half of the top milk and add the same quantity of distilled water, and repeat this process

several times until the suspended matter remains in pure water, which may then be collected on filtering paper and weighed before and after drying. If these sediments are subjected to microscopical examination, we shall find, as shown in the accompanying microphotographs, prepared by Dr. Gray, of the Army Medical Museum, that they are composed of epithelial débris, hairs of the cow, excrementitious matter, vegetable fibres, organic and inorganic dust particles, bacteria, fungi, and spores of every description; fully ninety per cent. of the germs are fæcal bacilli—all of which is not only disgusting, but extremely suggestive of danger. The number of micro-organisms in such milk is largely increased, and while there is no evidence that milk of this description, when taken perfectly fresh, has proved injurious to the consumer, we know that bacterial development and consequent decomposition are materially hastened in such a medium, and that the conversion of lactic sugar into lactic acid, apart from impairing the nutritive value, may cause gastro-intestinal disorders in delicate infants.

FIG. 3355.

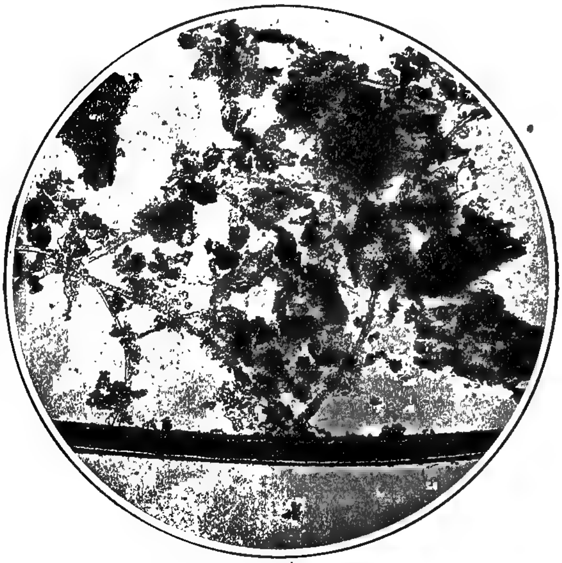

FIG. 3356.

FIGS. 3355 AND 3356.—Milk Sediments.

The greatest danger from milk of this class is the possible presence of tyrotoxicon and other toxins. Professor Vaughan believes that the former poison is developed by the growth of a saprophytic germ, which under favorable conditions multiplies with astonishing rapidity. The presence of the very filth referred to, a summer heat, and the pernicious habit of placing the milk before cooling in covered cans or bottles, perhaps dirty besides, constitute favorable environments for the development of this poison. Flügge (*Zeitschrift f. Hygiene*, July, 1894) found among the milk bacteria, especially those which are liable to resist the temperature of boiling, several varieties capable of evolving toxins. The views of Vaughan, Booker, Jeffries, Escherich, Baginsky, and others on the relation of saprophytic germs and toxins to cholera infantum and the summer diarrhœas in bottle-fed children are gaining ground and will doubtless lead to a great reform in the management of dairies.

Cases of poisoning by milk and ice cream were reported, long before we knew the nature of this poison, by Haschek, Hagner, Cameron, Barruel, Orfila, Marjolini, Bonorden, Hasset, Schroff, and others; the symptoms in these cases being nausea, vomiting, dryness and a sense of constriction of the throat, vertigo, colic, and purging, with a tendency in some cases to collapse, in others to numbness of the extremities and stupor.

In 1884 Vaughan isolated a poison found in poisonous cheese and called it *tyrotoxicon;* in November, 1885, he found the same substance in old milk; in June, 1886, he demonstrated its presence in poisonous ice cream, and in milk which had already undergone lactic-acid fermentation, and he called attention to the probable relation of tyrotoxicon to cholera infantum and other kindred diseases. In July, 1886, he found this poison in a sample of milk which had evidently caused the symptoms of cholera infantum in a babe seven months of age. In April, 1887, Dr. Stanton, the health officer of Cincinnati, demonstrated tyrotoxicon in poisonous cream puffs.

2. MILK MAY BE RENDERED UNFIT FOR USE BY IMPROPER FOOD AND CARE OF THE ANIMAL.—The disease described as milk sickness or trembles by some American writers, and characterized by great weakness, constipation, vomiting, fetor of breath, and muscular twitching, is believed to be due to cows feeding on Rhus toxicodendron. Cases of diarrhœa, and even severe forms of gastro-enteritis, have been traced by Sonnenberger, Ratti, and Mackay to the milk of cows and goats feeding upon meadow saffron and euphorbiaceous plants. The milk of animals fed on carrots, turnip tops, and the common artichoke, and often that which is yielded after they have been turned out to pasture for the first time in the spring, is changed in an unaccountable manner, and has frequently caused vomiting, abdominal pains, and diarrhœa in hand-fed children. Among the meadow plants, apart from species of Euphorbia and Ranunculus, Husemann regards the Gratiola officinalis, Æthusa cynapium, or fool's parsley, Cytisus ramentaceus, and different varieties of sorrel and mushrooms, as being especially objectionable.

The milk of swill-fed animals has often a peculiar taste and odor, and is said to cause hyperacidity of the urine and consequent eczema. M. Toussaint called attention to the fact that in the district of Argenteuil deaths from gastro-intestinal diseases have increased in frequency among bottle-fed children since the establishment of a large distillery, the cows being fed on brewers' grain and other distillery products, and the milk presenting an acid reaction. But this acidity is by no means constant, as Uffelmann and Ohlsen have often found it alkaline.

Ostertag states that the milk of animals fed with expressed sugar beets is destructive to calves on account of the excess of potassium, and hence objectionable for

human consumption. Bollinger reports injurious effects from castor-oil cakes, and Schmidt-Mühlheim attributes diarrhœal attacks to the admixture of wild mustard in the rape-seed-oil cakes fed to cows.

3. MILK MAY ACQUIRE INJURIOUS PROPERTIES WHILE THE ANIMALS ARE BEING TREATED WITH STRONG REMEDIAL AGENTS WHICH ARE EXCRETED IN THE MILK.—This is true of the following substances: arsenic, lead, iodine, copper, mercury, tartar emetic, carbolic acid, opium and morphine, colchicum, and euphorbium. Dr. James Law reports an extensive outbreak of ergotism among animals, affecting also calves, presumably through the milk; and Baum refers to salicylic acid, atropine, veratrum, strychnine, croton oil, aloes, senna, and turpentine as likely to affect the milk. The remedy is obvious; animals which are being treated with medicaments for any cause cannot produce a pure or sound milk and should be excluded.

Venomous Poison in Milk.—Dr. Francis reports a remarkable case of this kind, the details of which were furnished him by Dr. Fayrer, of Eastern Bengal, and which indicate that the milk of an animal bitten in the udder by a poisonous serpent will convey the venom.

4. MILK ITSELF MAY BE MORBIFIC AS THE PRODUCT OF A DISEASED ANIMAL.—(*a*) *Inflammatory Conditions of the Udder and Teats* (*Garget*).—There is an abundance of evidence to show that cows frequently suffer from various degrees of mammitis and other septic processes of this secreting organ. It is obvious that the character and composition of the milk in such instances are changed, and, apart from the disgusting admixture of pus, it may prove dangerous by the transmission of septic germs, such as the various forms of streptococci and staphylococci, which have actually been demonstrated in such milk by Kruger, Nocard and Mollerau, Kitt, Bang, and others; and, besides, we know from Löffler's experiments that milk also offers a suitable culture medium for such germs.

Dr. James Niven, health officer of Manchester, describes in the London *Lancet*, January 19th, 1895, p. 145, an epidemic affecting one hundred and sixty consumers of a particular milk supply, with symptoms of diarrhœa, sickness, and abdominal pains. The milk had an odor resembling that of sweet pus, and examination revealed the presence of streptococci and a microbe having the characters of the bacillus coli communis. A searching inquiry at the farm resulted in the admission of the farmer that he had sold a cow on November 8th because she was suffering with garget, and that her milk had been mixed with the other supply. A similar milk infection was reported by Dr. Boxall, in the London *Lancet*.

As a matter of fact, many of the epidemics of scarlet fever, diphtheria, and follicular tonsillitis in Great Britain have been attributed to a milk supply from animals suffering with local affections of the teats and udder. Thus, for instance, in November and December, 1885, an epidemic appeared at Marylebone, St. Pancras, and Hampstead, which Mr. W. H. Power, the sanitary inspector, traced to a particular milk farm at Hendon, but could discover no sign of scarlet fever at or near the dairy. Upon examination of the cows some of them were suffering from an ulcerative disease of the teats and udders; and from various other circumstances he inclined to the belief of the bovine origin of this disease. In 1869 Dr. J. Fagan described a case of pseudomembranous stomatitis produced by the milk of a cow with inflamed udder. On inquiry Dr. Fagan was informed by the mother that for some time past she had noticed a sediment of a dirty appearance in the bottom of the vessel. Microscopical examination of this sediment revealed corpuscles of both pus and blood, and on making further inquiry it was found that the cow had suffered from inflammation of the udder, which had at the time formed an abscess. In addition to Klein's testimony as to the presence of a streptococcus in these cases, Prudden reports twenty-four cases of diphtheria, in which in all but two he demonstrated a streptococcus, probably identical with the streptococcus pyogenes and streptococcus erysipelatis. Baginsky (*Berliner klin. Wochenschrift*, 1892, No. 9, p. 183) reports that of 154 cases of diphtheria treated under his supervision, in 118 cases Löffler's bacillus was present, while in the remaining 36 only cocci (staphylococci and streptococci) could be demonstrated. Guillebeau (*Landw. Jahrb. Schweiz*, 1892, p. 27) made an examination of the milk of seventy-six cows suffering from udder inflammation. In all cases he found the milk contaminated with pyogenic germs, and experiments convinced him that they were pathogenic in so far as they produced similar inflammation when inoculated in healthy animals. Adametz, Macé, and Hueppe observed several kinds of pus-producing germs under similar conditions, which multiplied to such an extent in the milk that the gases caused the cheese to "heave." When we further consider that toxins may and do produce a scarlatinous exanthem, we feel warranted in declaring that in all the epidemics of scarlet fever and diphtheria which were traced to milk from cows suffering with some inflammatory lesions of the udder or from puerperal fever, we have typical instances of a streptococcus and staphylococcus infection. These views were presented by the writer as early as 1895, and in August, 1897, Grey Edwards in the *British Medical Journal*, vol. ii., pp. 340-341, published cases of follicular tonsillitis, in which the staphylococcus pyogenes aureus and albus and the streptococcus pyogenes (short form) were not only found by Severn, director of a London Pathological Laboratory, in the suspected milk, and in the milk of a particular diseased cow, but also in the sweepings (culture) from the throat of the patient, and it will often be impossible to differentiate clinically such attacks from true diphtheria and scarlet fever. There is no proof that there is a disease in the cow which is communicable as scarlet fever or diphtheria to man, but when we consider the almost total absence of scarlet fever in countries like Japan, where milk is seldom used except as a medicine, the question should not be regarded as definitely disposed of, but is one that merits the most searching investigation by pathologists and bacteriologists of both medical and veterinary schools.

(*b*) *Fever, Especially Puerperal and Other Septic Fevers.*—The milk of animals suffering from febrile diseases is unfit for use. This is especially true of the puerperal and other septic fevers, in which Karlinski, Escherich, Longard, and Adametz have demonstrated the presence of the micrococcus pyogenes aureus in milk, the last-named author in a sample which had induced vomiting and diarrhœa. There is reason for believing that the germs of septicæmia neonatorum are in many instances conveyed in the milk, since Escherich, who examined thirteen specimens of milk from mothers suffering from puerperal fever, found the pyogenic germs in twelve, and Karlinski not only demonstrated the staphylococci in the milk of the mother, but also in the blood and intestinal contents of the infected infant.

(*c*) *Gastro-enteric Diseases.*—It has long been held that the milk of cows suffering from digestive derangements is of an abnormal character, and, according to Siedamgrotzky, Fröhner, and Bräuer, it is usually quite watery, of a bitter taste, and generally coagulates within from six to eight hours after milking, with the formation of very little acid, so-called "sweet curdling." When we remember that if nursing mothers indulge freely in fresh fruit and green vegetables their milk is apt to gripe and purge their infants, we can appreciate how cow's milk, under the above circumstances, may produce mischief.

(*d*) *Acute Specific Enteritis.*—Professor Gaffky has reported several cases with symptoms of nausea, vomiting, diarrhœa, and mental confusion, which he traced to the milk of an animal suffering from this disease, and demonstrated a characteristic organism in the animal as well as in his human patients. He also referred to Professor Husemann's report of an epidemic of gastro-enteritis which prevailed in 1888 at Christiania, and which within three weeks affected over six thousand persons, while sparing infants at the breast.

(*e*) *Foot-and-Mouth Disease* (*Eczema Epizootica*).—The milk from animals suffering from this disease is unfit for

use, and many epidemics of stomatitis aphthosa or aphthous fever have been reported. According to Dr. Salmon, of the Bureau of Animal Industry, this epizootic does not now prevail in the United States, the last cases having occurred in Maine some years ago. There is, of course, danger from a return of the disease at any time; it annually affects about ten per cent. of the cattle in Europe.

Mr. E. Hart described an epidemic at Aberdeen, which affected about three hundred persons with rigors, fever, tonsillar enlargement, and swollen cervical glands. The boys at the reformatory school, whence the milk came, receiving only skimmed milk, entirely escaped. The water supply of the dairy was bad, but no explanation of the epidemic was given. The symptoms resembled the outbreak at Dover in 1884, which affected in one week two hundred and five cases, all supplied with milk from one dairy, the cows at one of the farms suffering from foot-and-mouth disease. Baum refers to a number of instances in which the infection was conveyed in the milk.

(*f*) *Cowpox.*—Dr. J. M. Cotterill read, before the Medico-Chirurgical Society of Edinburgh, a paper in which he gave the history of two epidemics of sore throat which occurred at Fettes College. The first began in October, 1886, and comprised fifty cases; the second occurred a year later, and comprised eighty-four cases. The symptoms of the disease were as follows: When first seen the patients (all boys) were generally out of sorts, complaining of headache, want of appetite, and lassitude; occasionally there was sickness or nose bleeding; in most cases a furred tongue, foul breath, and other symptoms of gastric disturbances were present. The tonsils and posterior wall of the pharynx were bright red, with considerable swelling of the mucous membrane. The uvula and soft palate were also congested, but in no case was there any membranous deposit on these parts. Upon the tonsils and walls of the pharynx, however, there were always follicular exudations, and sometimes a considerable patch of deposit on the tonsils, which were often much swollen and deeply fissured. These patches could always be easily removed. Albuminuria was very frequent. The disease usually lasted about seven days in its acute stage. A peculiar symptom was the implication of the uppermost of the chain of lymphatic glands behind the sterno-mastoid. This always happened several days after convalescence had commenced. There would be a large brawny swelling in the neck, which in every case subsided slowly, without suppuration. Meantime the cows had been inspected by Professor Williams, and two of them had been certified to be suffering from variola vaccina in its later stages.

(*g*) *Anthrax.*—The milk of animals infected with anthrax is unfit for use, because Feser, Manotzkoff, Nocard, and others have actually demonstrated the bacillus anthracis in the milk, and if infection has not more frequently taken place it is because the secretion is arrested in the very first stage of the disease. Heusinger, however, refers to an instance which occurred in the daughter of a plantation owner, in 1795, at Barbadoes, who drank one morning most of the milk from a cow suffering with anthrax. Four days afterward the child presented symptoms of the disease. A carbuncle also appeared on the left arm. The direct transmission through the milk, although probable, has not been proven; still there can be no question as to the objectionable character of the milk.

(*h*) *Pleuropneumonia.*—It is claimed that the milk of animals suffering from this disease may convey the germs, and Lécuyer, Schüppel, Jürgensen, and others have actually reported a number of transmissions, but the question is by no means settled. Fortunately, the disease has been stamped out in the United States; at least Dr. Salmon informs me that not a single case has been reported for some years.

(*i*) *Rabies and Tetanus.*—In olden times the consumption of milk from rabid cows was regarded as dangerous, and Faber refers to a few instances of transmission of the disease in human milk, which all date back to the last century. Feeding experiments have proved in the majority of instances negative, and Hertwig, Bollinger, Reder, Fröhner, and others conclude from them that there was no danger from this source. Since Pasteur pointed out, however, that the mammary glands were among the organs selected for the deposition of the virus, there has been a renewed interest in the subject, and Nocard has experimentally proven that the virus may be conveyed in the milk. Burdach also determined, in the Pasteur Institute, that the milk of a woman bitten by a rabid wolf proved infectious to rabbits and guinea-pigs, but was quite harmless to the child. This question remains unsettled, as the accidental admixture of virus outside of the body in the Pasteur Institute is not excluded; but all authors agree that cows may suffer from hydrophobia, and that the milk should not be used. It is not improbable that the milk of animals suffering from tetanus contains some of the specific bacterial products, but it seems almost inconceivable that animals suffering from these affections should be milked at all.

(*j*) *Tuberculosis.*—While it is possible for milk to be contaminated with the sputum of tuberculous matter of consumptives, we are considering here the transmission of the germs from the animal to man through the medium of milk. When it is remembered that one-seventh of all the deaths are due to tuberculosis, and that the identity of bovine and human tuberculosis has been a source of contention for years, we need not wonder that much attention has been given to the study of milk from tuberculous cows. Dr. H. C. Ernst presents evidence from thirty-nine veterinarians representing seventeen States, most of them reporting for one year only, which indicates that there were 549 cases of tuberculosis and 242 suspicious cases, a total of 791 among 165 herds, representing about three thousand animals, *i.e.*, 18 per cent. of positively tuberculous animals and over 8 per cent. of suspicious cases, a total of about 26 per cent. According to Dr. Salmon it has been proved that in some countries from 40 to 50 per cent. of all cows have tuberculosis. In the United States the proportion is very much less, being probably not over 5 per cent. in our worst affected States. Yet there are many herds here as badly affected as the worst herds of Europe. The possibility of the presence of tubercle bacilli in the milk of animals was pointed out first by Virchow and by Koch as early as 1882, and subsequently the bacilli have been demonstrated by Bang, Johne, Bollinger, Ernst, Woodhead, MacFadyan, and many others, in the milk of animals in which the udder was also the seat of lesion, and for some time it was doubted whether the milk from a cow is virulent unless the udder is the seat of the tuberculous deposits. In 1893, Theobald Smith from a number of experimental observations finds that tubercle bacilli may be present in the milk of tuberculous cows when the udder, so far as the naked eye could tell, contained no foci of disease, and the result presented by Ernst in his report on the infectiousness of milk appears fully to justify the conclusion reached by him in 1889 that the milk from cows affected with tuberculosis in any part of the body may contain the virus of the disease. These conclusions are moreover supported by the investigations of Bang, Bollinger, Adami, May, Delépine, Stein, Rabinowitsh, Kempner, and Hirschberger, the latter being also the first to point out that the inoculation experiments are the more certain guide as to whether the milk is infectious or not, as he obtained positive results from milk of undoubted tuberculous animals, in which he was unable, however, to demonstrate the presence of tubercle bacilli. The general results of inoculation experiments would seem to indicate that the infectious qualities are greatest with milk from animals with udder lesions, and next from those affected with general tuberculosis. The feeding experiments of Bang, Bollinger, Klebs, Ernst, Baumgarten, Fisher, Wesener, and others, with tuberculous milk proved infectious in about forty-five to fifty per cent. of the cases. When we recall the fact that the last three observers in their feeding experiments were especially impressed with the resulting tuberculous lesions of the intestinal mu-

cosa, mesenteric glands, and liver; when we next consider the large mortality of children under five years from primary tuberculous ulceration of the intestines, tuberculous peritonitis and tabes mesenterica, and the fact that the food of these children consists largely of unboiled milk, the chain of evidence seems wellnigh complete, but has been materially strengthened by a number of clinical cases.

Professor Klencke, in an excellent little work published at Leipsic, in 1846, gives the clinical history of sixteen children who had been fed with milk from "scrofulous tuberculous" cows, and all point to tuberculosis of the intestines, glands, skin, or bone. In three of the intestinal disorders, he refers to the presence of indurated mesenteric glands. In this connection, the writer can hardly resist the conclusion that the difference in degree of virulence observed in the various tuberculous manifestations is perhaps not always attributable to the condition of the host, but may possibly be due to an attenuated character of the tubercle bacilli. Whether or not the German habit of boiling the milk, or adding boiling water, or the action of the gastric juice modifies the virulence of the bacilli, as shown by the slower forms of tuberculosis, remains to be seen; but in the feeding experiments with raw and boiled milk, of Bollinger in 1878, and Bang in 1890, a marked difference in the resulting lesions may be noticed.

Dr. Ernst's clinical inquiry on the transmission of bovine tuberculosis revealed the following facts: Among 1,013 replies from physicians, 895 were negative, 8 reported cases of infection of a child by the mother, 11 reported cases of infection by cow's milk, and 16 reported suspicious cases. The veterinarians gave much more striking evidence, since among 54 replies 14 reported positive and 9 suspicious cases. The positive replies quoted by Dr. Ernst are not such as will be considered conclusive evidence by pathologists and really lack scientific accuracy.

Johne, Hermsdorf, Leonhard, Demme, Sonntag, Meyerhoff, Stang, Schöngen, Uffelmann, Brouardel, Ollivier, and others have reported instances of transmission in which all other causes could be reasonably excluded. The entire subject still requires careful consideration, and the work of Klencke, who as early as 1846 described the condition of the patients, the cows supplying the milk, and the post-mortem appearances, should serve as an example for investigators in this field.

5. Milk may Acquire Infective Properties After it Leaves the Udder of the Animal.—Numerous instances have been observed in which outbreaks of typhoid fever, scarlet fever, and diphtheria, by their sudden and explosive character, affecting families living in streets and localities supplied by the same milkman, naturally pointed to the milk supply as a common cause. Dr. Michael Taylor, however, was the first physician (in 1857) to point out definitely that cow's milk might serve as the medium of spreading typhoid fever from a dairy where the disease prevailed. In 1867 he also showed that scarlet fever might be distributed in the same way. In 1877 Mr. Jacob traced a diphtheria epidemic at Sutton to the milk supply, and in 1872 Macnamera traced an outbreak of cholera at Calcutta to an infected dairy. These facts could not fail to sharpen the powers of observation in others, and in consequence similar outbreaks were more frequently reported, so that Mr. E. Hart, the editor of the *British Medical Journal*, was enabled to present to the International Medical Congress, held in London in 1881, the history of 50 outbreaks of typhoid fever, 15 of scarlet fever, and 7 of diphtheria, all traceable to the milk supply. In a similar communication made before the International Medical Congress at Paris, in 1900, the writer presented his conclusions based upon the tabulated histories of 330 outbreaks of infectious diseases spread through the milk supply; these outbreaks consist of 195 epidemics of typhoid fever, 99 epidemics of scarlet fever, and 36 epidemics of diphtheria.

It has been demonstrated by numerous bacteriologists that disease germs may not only survive, but in many instances actually proliferate in the milk; and it is not a difficult matter to point out the many ways by which these germs gain access, especially when some of the employees are also engaged in nursing the sick, or are suffering themselves from some mild infection while continuing their duties, or are convalescent from the disease. It is quite conceivable how animals wading in filth and sewage-polluted water may infect the udder with the germs of typhoid fever and through it the milk. We can also appreciate how infected water may convey the germs by washing the utensils or by deliberate adulterations. Infection may also take place through the agency of scrubbing-brushes, dishcloths, exposure to infected air, and the agency of flies.

(*a*) *Typhoid Fever.*—Of the 195 epidemics of typhoid fever tabulated by me, there is evidence, in 148, of the disease having prevailed at the farm or dairy. In 67 instances the infection probably reached the milk by percolation of the germs into the well-water with which the utensils were washed; in 16 of these the intentional dilution with water is a matter of evidence. In 3 instances the bacillus coli communis and the typhoid germs were demonstrated in the suspected water. In 7 instances infection is attributed to the cows wading in sewage-polluted water and pastures; in 24 instances the dairy employees also acted as nurses; in 10 instances the patients, while suffering from a mild attack or during the onset of the disease, continued their work, and those who are familiar with the personal habits of the average dairy hands will have no difficulty in surmising the manner of direct digital infection. In one instance the milk tins were washed with the same dishcloth which had been in use among the fever patients. In two instances the dairy employees were connected with the night-soil service, and in another instance the milk had been kept in a closet in the sick-room.

(*b*) *Scarlet Fever.*—Of the 99 epidemics of scarlet fever the disease prevailed, in 68 instances, either at the dairy or at the milk farm. In 6 instances persons connected with the dairy either lodged in or had visited infected houses In two instances the infection was conveyed by means of infected bottles or milk cans left in scarlet-fever houses. In 17 instances the infection was conveyed by persons connected with the milk business while suffering or recovering from the disease, and in at least 10 instances by persons who acted as nurses while handling the milk. In 3 instances the milk had been stored in or close by the sick-room. In one instance the can had been wiped with an infected cloth. In 19 instances the infection was attributed to disease of the milk cows, such as puerperal fever and inflammation of the udder and teats; but these outbreaks were probably not genuine scarlet fever, but a so-called streptococcus or staphylococcus infection, the symptoms of which closely resemble those of scarlet fever.

(*c*) *Diphtheria.*—Of the 36 outbreaks of diphtheria tabulated there is evidence that the disease prevailed at the dairy or farm in 13 instances. In three instances the employees continued to handle the milk while suffering themselves from the disease. In 12 instances the disease is attributed directly to the cows having inflammatory conditions of the teats and udders. These instances, however, may be regarded as typical examples of streptococcus and staphylococcus infection, giving rise to a form of follicular tonsillitis or pseudodiphtheria, often difficult to distinguish clinically from true diphtheria or scarlet fever.

(*d*) *Cholera.*—Professor Koch, in 1884, first pointed out that milk is a suitable culture medium for the cholera bacillus, but the possibility of the virus being transmitted in the milk had been emphasized before. Gaffky, in the report of the Cholera Commission in India, refers to the unsanitary condition of the dairies in India, where the water supply is derived from tanks which are promiscuously used for bathing, laundry, and dairy purposes, and as Dr. Payne, the health officer of Calcutta, in his report in 1876, expressed it, "milch cows are stalled in the neighborhood, and the nearest water is freely mixed with

the milk and distributed through the town." Dr. Cayley refers to the fact and consequent danger that at Katarbatti, a suburb of Calcutta of 300 families, 70 are engaged in the milk business, all located near one of these notorious water tanks, and that in September, 1872, not less than 16 cholera cases with 6 deaths occurred among these dairy people.

Dr. Macnamera reports an outbreak in a boarding-house at Calcutta attacking six Europeans and the cook of their department, while the other inmates and servants of the house escaped. They had all consumed the milk from a particular dairy, and it was determined that immediately before this outbreak eight cases of cholera had occurred in close vicinity of the water tank used by this milkman. Dr. Simpson, health officer of Calcutta, describes a limited epidemic which occurred on board the ship *Ardenclutha* resulting in nine cases and four deaths, and affecting, with one exception, consumers of a particular milk derived from a dairy located near a tank into which dejecta from a cholera patient found access, and the dairyman, with unusual frankness, admitted the dilution of the milk with about one-fourth of water from this source. Hesse claims that cholera germs will not survive in fresh raw milk; Basenau maintains that they retain their vitality and increase in number up to the point of coagulation, while Weigmann and Zirn declare that their activity is largely influenced by the number of other germs present.

It is interesting to note that of the 330 milk-borne epidemics analyzed by me, 243 have been recorded by English authors, 52 by American, 14 by German, 11 by Scandinavian, and 5 each by French and Australian writers. This is probably due to the fact that the English and Americans usually consume raw milk, while on the Continent the milk is rarely used without being boiled.

Adulteration of Milk.—According to the United States Census of 1900, we have 18,112,707 milch cows with an average annual production of 7,728,583,350 gallons of milk, 186,921,787 gallons of condensed milk, 1,492,699,143 pounds of butter, and 298,905,404 pounds of cheese. These figures furnish an indication not only of the extent of milk consumption but also of the amount of danger from an impure supply, and lastly of the temptation which still exists, from a monetary point of view, for the practice of shameful adulterations. The most frequent of these are the intentional dilution with water, the removal of cream, and the addition of skimmed milk. The former, apart from diminishing the nutritive value of the milk, a matter of great importance, is often the immediate cause of transmitting disease germs, if the water happens to be infected. A very common fraud appears to be the removal of cream and adding just enough separated milk until the amount of fat present is on the limit that will pass inspection. The introduction of cream separators affords an opportunity of removing almost the whole of the fat from the milk, and the sophisticator has thus the power of reducing its cream to the lowest salable standard without exposing himself to any such risk of detection as would attend the process of "watering," a process by which the total non-fatty solid might be so reduced as to lead to the detection of the fraud. Indeed Spiegelhalter, of St. Louis, from a large number of examinations, concluded that the fraud by removal of cream in that city amounts to 1,600 gallons per day, or a loss of about $900,000 per annum, largely made up of the pennies of poor and sickly women and half-starved children. Similar testimony has been recorded regarding the milk supply of other cities. Dr. W. H. Kent, the chemist of the Brooklyn Department of Health, in March, 1889, examined a number of samples of condensed milk with reference to previous skimming, and from the results he concluded that 17 of the 23 different brands were made from milk the cream of which had been more or less removed. The glaring cases which come under the notice of the authorities afford no evidence as to the actual extent of these frauds, but they simply show that in these instances the milk had been so recklessly treated as to pass beyond the limit of a low official standard of milk. Formerly it was almost impossible to secure conviction on account of the difficulty of proving the addition of water or removal of cream, for there are instances of deficiency of solids in milk known to be genuine and the charge of fraud or criminal knowledge could not always be sustained.

Milk Standards.—These difficulties and the fact that the composition of milk varies greatly with the breed and feed of the animals, climate, and season, led to the adoption of legal standards of milk offered for sale. There are instances of analysis in which the total solids fluctuated from 10.33 to 15.83 per cent. and the fat varied in the same manner from 2.43 to 5.97 per cent. If between these limits a high standard were fixed the result would be to condemn much genuine milk, while if a low standard were adopted, it would virtually legalize dishonest manipulations of the milk or else place a premium on indifferent care and breed of the dairy stock. Indeed, if we follow up cases of poor milk to their source, we usually find half-starved or badly cared-for cows, and for obvious reasons we can only deal with averages based upon a large number of samples and which, while fulfilling modern sanitary requirements, are also just to the producer. As a result of the analyses obtained by different chemists covering over 120,000 samples of milk, we have a right to expect a milk containing 12.50 per cent. of total solids, composed of 8.75 per cent. non-fatty solids and 3.75 per cent. of fat, and also that the legal standards which vary in different States be modified accordingly.

By the adoption of legal standards the prosecution of milk sophisticators has been simplified, for by prohibiting the sale of milk below a fixed standard the question of fraud or adulteration need not be proven, and the allegation that it is below the prescribed standard can be sustained by the results of the analysis and suffices for conviction, regardless of the fact whether it is the product of fraudulent practices or the peculiarity of individual cows or their care.

Adulterants Most Commonly Used.—In order to conceal adulteration with water or the removal of cream and other fraudulent practices, all sorts of substances have been added. Lengfelt, of San Francisco, communicated to Professor Wiley the composition of a milk adulterant commonly used in that city and consisting of common salt, saltpetre, saleratus, a trace of caustic soda, and a large quantity of sugar and colored with caramel. Chalk, gypsum, starch, finely ground calves' brains, and gelatin figure among the recorded instances of adulterants, but it is about time that the popular fallacy of chalk and water mixtures and emulsions of calves' brains should be dispelled. A moment's reflection will indicate that chalk and water would have to be constantly stirred and that calves' brains are too expensive, and moreover quite unsuited for such a purpose. Starch and gelatin are occasionally used, and Harrington reports that a preparation largely advertised to the trade at one time as a "cream thickener" was analyzed by him and found to be a mixture of gelatin, borax, and boric acid. Annatto, turmeric, yellow coal-tar colors, and even chromates have been employed to give a rich yellow color to poor or watered milk, or during the winter season when the cream has not the characteristic yellow tint.

Preservation of Milk.—Bitter, an authority on sanitary milk, maintains that the maximum limit for milk that is fit for food is 50,000 germs per cubic centimetre. Dr. Turner, the Dairy Inspector of the District of Columbia, found only 52 of the 117 samples examined by him to contain less than 50,000 per cubic centimetre, while most of the samples showed a higher number of bacteria than the sewage of the city. The changes due to bacterial action have been described under "Bacteriology of Milk," and the effects of such changes have been pointed out in the section relating to Milk Sediments, on page 834. The multiplication of milk bacteria goes on most rapidly at a temperature of between 70° and 85° F., and they practically cease to proliferate at a temperature below 50°. In order to reduce the number of germs to a mini-

mum, it is necessary to reject the first strippings of the milk, because it has been shown by Schultz and Moore that the foremilk always contains an excess of bacteria, which have invaded the lacteal ducts and multiplied since the previous milking. Absolute cleanliness of animals, stables, milking-rooms, utensils, employees, and the very air, are equally essential. This has been demonstrated by Sedgwick, Batchelder, Freeman and others. Freeman's experiments are especially instructive; he exposed three plates, each three and a half inches in diameter, for two minutes as follows: one in the open air, one outside a barn, and a third in front of the milk pail under a cow in the same barn while the milking was going on. The first showed 6, the second 111, and the last plate 1,800 colonies, and strikingly illustrates the dangers of dust being stirred up. Next to clean and intelligent methods in milking, the temperature of the milk should be quickly brought down to 40° F., kept cool, and delivered to the consumer at a temperature below 50° F., so as to inhibit the growth of the micro-organisms. That this can be done is shown by the fact that the average number of bacteria in the product of a sanitary dairy in the city of Washington was only 6,485, against 52,000 per cubic centimetre, found in average market milk. This involves, to be sure, the free use of ice and its transport in refrigeration cars, but milk of this character can be sold with a good profit at ten cents per quart. In some parts of Europe a portion of the milk is frozen into solid blocks by the ammonia process and placed in the shipping cans to keep the other milk at a low temperature.

Heat has been employed as a preservative because the operation of certain temperatures destroys the vitality of the germs. Two methods have been proposed, viz.: sterilization and pasteurization. *Sterilization* is usually accomplished by boiling the milk for ten minutes, which is sufficient to destroy all living organisms, including, of course, disease germs; a longer exposure is necessary, however, for the destruction of the spores of the anthrax bacilli, although continuous heating under pressure for two hours at a temperature of 248° F. accomplishes the same purpose. The formation of the coat on top consisting of fat, casein, and lactalbumin, can be prevented by boiling the milk in a long-necked bottle. In boiling, milk loses its gases and aromatics, and also some of its watery constituents, part of the sugar is converted into caramel, and the proteids and salts are also modified; these and other modifications which have been pointed out in Dr. Blackader's article, Vol. IV., p. 866, affect the digestibility of the milk, and rickets and scurvy have been attributed to this cause. For these reasons *pasteurization*, or the exposure of the milk for from ten to fifteen minutes to a temperature of 158° F., was regarded as a distinct advantage. The milk does not acquire a cooked taste, but in order to inhibit the growth of some of the more resistant organisms and their spores, the temperature of the milk must be promptly reduced to 50° F. and kept there, and if need be the process can be repeated in twenty-four hours, and thus the keeping qualities increased. Bitter prefers a temperature of 155° F. for thirty minutes, while others maintain that a temperature of between 140° and 147° F. suffices for the destruction of all pathogenic organisms; but Theobald Smith's experience with the tubercle bacillus shows the necessity of a temperature of 149° F., and, on the whole, Bitter's limit of 155° F. ought not to be lowered.

It is claimed by quite a number of physicians that the operation of even such low temperatures impairs the digestibility and nutritive qualities of the milk, and that preference should be given to raw milk obtained under special sanitary precautions. Unless, however, the milk is obtained from dairies operated under special milk commissions, the writer strongly urges pasteurization as the lesser evil of the two; indeed, he believes that the dangers of pasteurized milk have been exaggerated, and the question of incomplete absorption of the salts as a cause of scurvy and rickets has not been sufficiently considered. These diseases are most frequently developed in children after prolonged diarrhœal affections, and the diarrhœa, and not the modified character of the component parts of the milk, may be responsible for the incomplete absorption. To overcome the objections to pasteurization of milk, Freeman recommends that the cream be allowed to rise, and as it carries about ninety-nine per cent. of the bacteria along to the surface, it will be sufficient to sterilize the cream only. This suggestion has been before the profession only a few years, and sufficient time has not elapsed to determine its merits.

Chemical Preservatives.—In order to promote the keeping qualities of milk, the use of antiseptics has been invoked by farmers who ship milk by railway to the city. The agents which have been used are borax and boracic acid, salicylates, benzoates, formalin (a forty-per-cent. solution of formic aldehyde) and sodium chloride, carbonate of sodium, saltpetre, and chromates. Of late years most of these chemicals except formaldehyde have fallen into disuse. According to the tests made by Dr. C. P. Worcester, quoted by Harrington, 1 part of commercial formalin in 100,000 parts of milk will postpone the curdling point 6 hours: 1 in 50,000, 24 hours; 1 in 20,000, 48 hours; 1 in 10,000, 138 hours; 1 in 5,000, 156 hours. Rideal and Fullerton regard formaldehyde in the proportion of 1 to 50,000 as an effective preservative of milk for 24 hours, and although it is claimed that in this strength, even during extended periods of use, this substance appears to have no injurious effects upon the consumer, the writer protests against the use of this or any other chemical preservative, so long as we possess in clean methods and cold storage a more rational and natural method. It must be remembered that few of these agents are normal constituents of the body and that their ingestion can do no good and may do harm.

Boric Acid and Borax are generally used in combination, and in order that it shall act as a preservative it is necessary that about ten grains of the mixture shall be added to a quart of milk. Prof. R. H. Chittenden reports that borax retards the amylolytic action of saliva, boric acid in amounts less than one per cent. favor it, and that both substances increase gastric digestion in small amounts and retard it in large. Foster and Schlenker found that boric acid limits albumen digestion and produces increased exfoliation of the intestinal epithelium, and also increased phosphoric acid elimination. Dr. H. E. Annet, in the London *Lancet*, November 11th, 1899, presents the results of his studies of boric acid and formalin as milk preservatives, and regards them as injurious especially to young infants.

Sodium Carbonate has been used more for the purpose of neutralizing acidity than as a preservative. It forms a lactate of soda which is believed to be a mild cathartic. Saltpetre, the salicylates, benzoates, and chromates are rarely used in this country, although reports from Europe indicate their occasional employment, especially that of the chromate and dichromate of potassium. Professor Hird, chemist of the Health Department, D. C., informs the writer that as a result of his crusade against the use of preservatives he encounters only now and then samples of milk containing formaldehyde.

Milk Inspection and the Methods of Detecting Adulterations and the Preservatives of Milk.—It is practically impossible to examine all the milk brought to a large city, nor is this necessary, provided the examinations are sufficiently frequent to cover within a reasonable time all the establishments connected with the milk traffic. Accurate records should be kept of these examinations, which should be directed to the determination of the most common forms of adulteration, viz.: (1st) milk which has been robbed of its cream and offered for sale as sound milk; (2d) milk which has been diluted with water; (3d) milk which has been creamed and watered; (4th) milk which is reduced by the addition of skimmed milk; (5th) milk to which various substances have been added to conceal adulterations; (6th) milk to which preservatives have been added. The methods usually employed by milk inspectors when dealing with a large number of samples are limited to the determination of the specific

gravity and the estimation of fats by which at least the suspicious cases can be singled out, and when found, liberal samples should be taken for the more accurate methods of the official laboratory.

In some States the authorities depend chiefly upon the lactometer. The normal average specific gravity allowed is 1.030 at 60° F., or 1.029 at 70° F. If the spindle floats below 29°, the inspector usually concludes that the milk is probably watered, or if it floats above 33° that it has been skimmed. As a matter of fact, however, an excessive amount of cream might diminish the specific gravity of a really rich milk, and the inspector should take this into consideration as well as the fact that the removal of fat raises the specific gravity, and the addition of water lowers it, rendering it quite possible that a milk which has been creamed and watered may have a normal specific gravity. For all these reasons a chemical analysis should be required, in order to secure conviction; and, so far as the methods for the determination of fats, milk sugar, proteids, and mineral matter are concerned, the reader is referred to Dr. Ladd's article on *Milk* for the desired information.

The Presence of Nitrates and Nitrites in milk is suggestive of adulteration with water derived probably from a polluted source. For the detection of these salts E. Pfeiffer recommends the following: Add sufficient acetic acid to 50 c.c. of the milk to precipitate the casein, filter carefully, boil the solution and filter again, acidulate 20 c.c. of the filtrate with one drop of pure sulphuric acid, and add small quantities of powdered diamidobenzol; a change to a yellow color indicates the presence of nitrous acid.

Also place 0.5 gm. of diphenylamin in a clean porcelain capsule or test tube and pour about 2 c.c. of pure concentrated sulphuric acid over it; then drop along the side of the capsule or test tube one or two drops of the above filtrate; the development of a blue color indicates the presence of nitrites or nitrates (Soxhlet).

Bacteriological Examination.—Since it has been claimed that nitrates and nitrites may be present in the milk if ingested by the animal either in water or in food, it will be well to examine the milk and suspected water also bacteriologically, which has become a well-recognized procedure, with a view of determining not only the number, but also the character of the germs, especially of the sewage group. Milk containing over fifty thousand germs per cubic centimetre is practically unfit for food, and for infant feeding the number should not exceed five thousand per cubic centimetre. Since milk may contain such a large number and variety of liquefying organisms as to spoil the plates, the phenol methods should be employed, and it is also best to make a number of plates in which the drop of milk has been diluted with sterilized water in various proportions, properly labelled and exposed to a temperature not exceeding 68° F. With this precaution the inspector may proceed with his technique, with which it is presumed that he is fully familiar.

Detection of Starch is usually accomplished with the microscope, also by the blue color developed on the addition of tincture of iodine to the milk previously heated to the boiling point and then cooled.

Detection of Gelatin in Cream.—Stokes recommends the following: Dissolve some mercury in twice its weight of strong nitric acid (specific gravity 1.420), dilute with water to twenty-five times its bulk; to about 10 c.c. of this solution add a like quantity of the cream and about 20 c.c. of cold water; shake the mixture vigorously; leave it for five minutes, then filter. If much gelatin be present it will be impossible to get a clear filtrate. To the filtrate or a portion of it add an equal bulk of a saturated aqueous solution of picric acid. If any gelatin be present a yellow precipitate will be immediately produced. The whole operation is performed in the cold, and if the mercury solution is ready, it will not take more than ten minutes. Picric acid will show the presence of 1 part of gelatin in 10,000 parts of water.

DETECTION OF ADDED COLORING MATTERS.—*Annatto.*—Add a few cubic centimetres of sodium carbonate solution to about 100 c.c. of milk to insure a strongly alkaline reaction during the examination, and then immerse a slip of heavy white filter paper, allowing it to remain over night in a dark place. The strip is withdrawn from the milk, gently washed in running water, and laid upon a piece of similar paper; it will present a distinct salmon tint if annatto is present in the proportion of 1 to 100,000. On dipping the paper into stannous chloride the color is changed to pink (Harrington).

Coal-Tar Colors.—According to Leffmann and Beam, these colors are detected by adding to the milk ammonium hydroxide and allowing a small piece of white wool to remain in it over night. The dye is taken up by the wool, which acquires a yellow tinge. When milk contains Martin's yellow, ammonium hydroxide intensifies the color, and hydrochloric acid bleaches it.

Chromates, according to Guérin, are detected by the following method: To 5 or 10 c.c. of milk add two drops of a one-per-cent. solution of sulphate of copper and two or three drops of freshly prepared tincture of guaiacum. Pure milk gives a greenish color; while milk containing 1 part in 100,000 of chromate will give an intense blue which reaches its maximum in a few minutes.

Caramel.—Harrington's method is as follows: Pour from 125 to 250 c.c. of the suspected sample into an equal volume of ninety-five-per-cent. alcohol and filter. The filtrate, if not perfectly clear, must be returned and passed through until it is quite free from turbidity. Any caramel present will be in solution in the alcoholic filtrate and may modify considerably its color, which is normally yellowish or greenish according to season, the latter obtaining in spring and summer. To 100 c.c. of the filtrate add 2 c.c. of solution of basic acetate of lead, which will precipitate the caramel together with any remaining proteids, the precipitate showing a slight brownish color if caramel has been used in sufficient amount to bring about the improved appearance, which is the object of its employment. Filter, wash with distilled water, and dry in an air-bath; according as the amount of caramel present is large or small, the horny residue on the filter paper will have a more or less deep chocolate tinge. The residue yielded by a pure milk will be either almost colorless or yellow, or slightly inclined to brownish, but not to chocolate color.

Determination of Free Lactic Acid.—Pfeiffer recommends to mix 10 c.c. of milk with 40 c.c. of water and 1 c.c. of a concentrated solution of phenolphthalein (made with fifty-per-cent. alcohol). The acid is now neutralized by gradually adding one-tenth normal soda solution until a pink-rose color develops. It is not necessary to calculate the result in lactic acid, as it is sufficient for comparison to state the numbers of cubic centimetres of the soda solution used.

DETECTION OF PRESERVATIVES.—*Determination of Sodium Carbonate* is most readily accomplished by E. Schmidt's method: 10 c.c. of the suspected milk are mixed with 10 c.c. of alcohol, and a few drops of a one-per-cent. solution of rosolic acid are added. If the carbonate or bicarbonate of soda be present, a more or less intense pink or rose-color is developed, while pure milk presents a brownish-yellow reaction; for comparison it is best to test milk known to be sound.

Determination of Salicylic Acid.—Fifty cubic centimetres of the suspected milk are treated with sulphuric acid for the removal of the proteids and fat and filtered. The filtrate is shaken violently with the same quantity of ether, and after separation of the ether the liquid is evaporated in a porcelain capsule, the residue is dissolved in a little alcohol, and a few drops of a neutral solution of ferric chloride are added. If salicylic acid be present even in traces, a characteristic violet color develops.

Determination of Boric Acid is best accomplished by Meissel's test: 50 c.c. of suspected milk are rendered alkaline with milk of lime, evaporated and washed. The residue is dissolved in strong muriatic acid; this solution is filtered and evaporated to dryness. The residue is moistened with sufficient very dilute muriatic acid to give it a soft consistency, mixed with tincture of turmeric

and dried on the water-bath. If boric acid be present the residue develops a cherry-red color, which does not disappear when diluted with water. A little of the ash may be moistened with just sufficient alcohol and ignited, when a greenish flame reveals the presence of boric acid.

Determination of Formaldehyde in Milk (*Method by Decolorized Fuchsin*).—Through a solution of fuchsin, 1 to 500, pass a current of sulphurous acid gas, obtained by heating copper wire or foil with sulphuric acid until the color is discharged. Preserve in a glass-stoppered bottle. To 10 c.c. of milk add 1 c.c. of the reagent and let it stand ten minutes. Add 2 c.c. of strong hydrochloric acid and shake or stir briskly. The color which appears in the first instance is completely discharged by the acid if no formaldehyde is present, otherwise a violet-blue tinge remains. If the amount present is large the end color will be correspondingly intense. This method will detect the admixture of 1 part of formalin in 50,000 parts of milk. If the milk be first distilled and the first part of the distillate treated with the fuchsin solution, the test is delicate to the extent of revealing 1 in 500,000 (Harrington). The phloroglucin and Hehner's tests are also very reliable.

Phloroglucin Test.—Dissolve 1 gm. of phloroglucin in 100 c.c. of distilled water. Put 10 c.c. of the suspected milk in a test tube, and add 5 c.c. of the phloroglucin solution; shake and add 1 c.c. of solution of potassa, United States Pharmacopœia. If formaldehyde is present a red color is developed at once, fading usually within five or ten minutes; hence the color must be observed at once. One part in twenty thousand gives a decided reaction.

Hehner's Test.—To 15 c.c. of concentrated sulphuric acid in a test tube add one or two drops of ferric chloride test solution, United States Pharmacopœia, and mix. Then pour upon this, in such manner as not to mix the layers, the suspected milk. A violet color indicates the presence of formaldehyde. In the case of cream dilute the cream with an equal volume of water, and then apply the test as above described. The violet color is sometimes produced at once, but oftener not for five or ten minutes, and sometimes not for an hour or so, depending upon the amount of formaldehyde present. By this test 1 part in 10,000 or 15,000 is readily detected.

FIG. 3357.—A Walker-Gordon Barn at Burnside Farm, Baltimore County, Maryland, U. S. A. Floor and feeding alleys continuous and connected by an unbroken curve with the lower side of windows; absolutely waterproof; drained and trapped; composed of granolithic pavement. Stalls hardwood, dressed with waterproofing so as to admit of complete washing. Roof ceiled with cement plaster. Ventilators regulated to admit air but exclude draughts. Windows opened or shut with continuous rods so as to regulate them easily and perfectly. Ties or tie-ups, galvanized pipe-iron bent to compel cows to stand back when up and fitted with cross chains to prevent cows from lying down between grooming and milking. Drinking cups, galvanized iron, connected with large boilers for boiling out and sterilizing. Overhead tracks for carriage of food into barn and manure away from it. Bedding employed, kiln-dried spruce shavings. Cubic air space per cow, twelve hundred feet.

Control, Management, and Inspection of Dairy Farms.—Sufficient data have been given to furnish the inspector with a basis for his examination and the accomplishment of fruitful results. Pure natural milk can be secured only at dairies with sanitary buildings, a pure water supply, healthy, well-fed and well-cared-for cows, a well-

equipped and well-kept milk-room, provisions for thoroughly sterilizing all utensils, intelligent people in charge, and cleanly methods throughout. There are a number of persons—thanks to the training received at the various dairy schools—who make an honest effort to place on the market milk obtained under such conditions, but by far the majority are ignorant or wilfully indifferent to hygienic requirements, and therefore matters of this kind should never be left to the individual, but the principles which ought to be carried out should be embodied in effective laws, and accepted and executed in a practical sense. Honorable men will not object to laws placing dairies, the herds, and the milk market under strict sanitary control, and as many of the most serious dangers are the result of ignorance, rather than of intentional negligence, the difficulties will be materially lessened by proper education and trade competition. It is highly desirable that some uniform legislation, preferably a national pure-food law, be enacted to regulate the inspection of dairy farms, etc., for, as it is now, milk consumed in New York City, for example, may be produced in a number of States over which, of course, the local authorities have no jurisdiction. A compulsory inspection of the dairy herds will be a source of ultimate profit to the owner, as the presence of tuberculosis or other communicable diseases endangers his entire herd, and great losses can be prevented by the extermination or isolation of the first case. The farmer will also find it to his advantage if he is obliged to house his cattle in spacious, well-ventilated and lighted stables (at least six hundred cubic feet of air space and nine feet window space for each animal, with good cemented floors, proper drainage, clean hay, straw, or shavings for bedding, and a standard ration.

The Feed and Care of Cows.—The animals should not be allowed to feed upon pastures with stagnant water or noxious weeds such as meadow saffron, henbane, Jamestown weed or stinkweed, poppies, mustard, carrot tops, milkweed, poison oak, sumach, skunk cabbage, and other euphorbiaceous and ranunculaceous plants, nor upon the swill or products from distilleries, breweries, glucose factories, etc. The use of turnips, kohlrabies, rutabagas, carrots, mangels, and the leaves of all kinds of root crops are also objectionable.

An abundance of wholesome pasture in season with hay and meal fodder should be allowed. At some of the "milk-cure institutes" in Germany each cow is allowed daily 10 pounds of meadow hay, 17 pounds of clover hay, 6 pounds of hulled barley meal, and 4 pounds of wheat flour. The United States Department of Agriculture recommends the following:

Adjustment of Ration to Milk Yield.—In making allowance for the difference in milk yield of different cows, a uniform basal ration can be fed to all the cows, and the amount of the richer grain mixture varied to suit the demands. For example, a basal ration might be made up of 25 pounds of corn silage, 8 pounds of rowen hay, and 3 pounds each of cornmeal and wheat bran, which would supply 1.43 pounds of protein and a fuel value of 23,712 calories. To this could be added a richer grain mixture composed of two parts of gluten meal and one part of cotton-seed meal, the amount of this being varied according to the milk yield of the cow. Two pounds of this mixture would bring the ration up to 1.97 pounds of protein and 26,999 calories, which would meet the requirements of cows giving from 12 to 15 pounds of milk a day, while 4 pounds would bring it up to 2.50 pounds of protein and 30,286 calories of heat, suitable for the cows giving from 20 to 25 pounds of milk, and so on, 5 or 6 pounds of the grain mixture being fed to the heavier milkers.

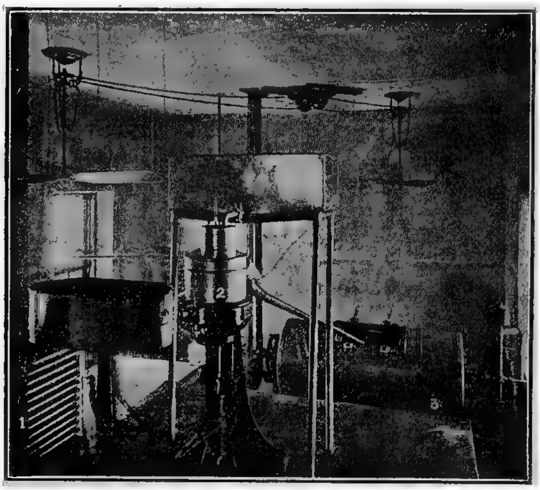

FIG. 3358.

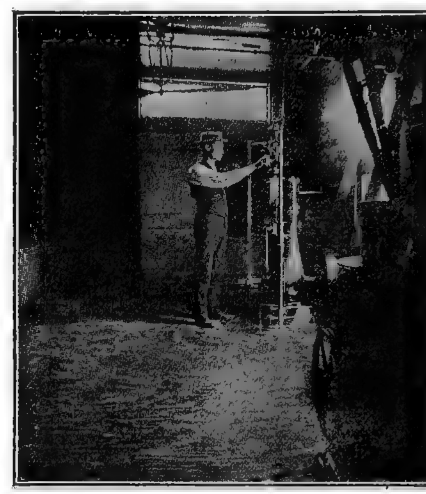

FIG. 3359.

FIGS. 3358 AND 3359.—Separating, Pasteurizing, and Cooling Department at Senator Stewart's Farm near Washington, D. C. 1, Cooler; 2, separator; 3, pasteurizer.

The water supply should be pure and closely guarded against pollution. In the absence of a spring, a deep-driven well should be preferred. While it is true that at the majority of dairy farms wells and privies are dangerous neighbors, the agency of flies in carrying infection should not be underrated, and points to the necessity of prompt disinfection; an effort should also be made to get rid of the flies by prompt disposal of the horse manure in which they breed, the abandonment of open privies and surface pollution, removal of garbage, and other fly-breeding matter. The animal should be groomed, and the teats and udders washed with sterilized water before milking; this is of importance, as the presence of fecal bacteria in milk is next in danger to disease germs.

Milking and Care of Milk.—The requirements of cleanliness apply with equal force to the milkmen, their person and clothing, and they should be required to keep their finger-nails clean from dirt and make a careful toilet before milking. The milking should be done in a dust-free atmosphere, preferably in a special room with cemented floors, previously sprinkled in order to reduce the number of germs to a minimum. It is impossible to secure bacterial purity of the milk when the milking is done in a stable with a hayloft above. The best results observed by the writer were obtained at a dairy supplied with one-story frame stables, cemented floors, well

lighted and ventilated by windows and Ridge ventilators, and where the animals after grooming were taken into a similarly constructed room for milking. Attention has already been called to the necessity of absolute cleanliness of the utensils and bottles, which can be accomplished with a weak solution of boiling soda water, subsequently rinsed in sterilized water. Before bottling, the milk must be rapidly cooled to a temperature of 40° F. and delivered to the consumer at a temperature not exceeding 50° F.

Sickness among Milkers and Employees.—All persons engaged in handling the milk should be free from disease. No family ever thinks of employing or keeping a cook afflicted with a communicable disease, and yet not the slightest restriction is placed upon, nor a question asked about, the persons who handle our milk supply, which we know affords an excellent culture medium for disease germs. After the recital of numerous epidemics and milk-borne diseases, we need hardly insist upon the necessity of compulsory notification of all infectious diseases, and that the milk should not be permitted to leave a farm, dairy, or milk-shop during the existence of any of these diseases among the inmates or employees, nor should the latter be permitted to reside in or visit infected premises while engaged in the milk traffic, without permission from the Health Department. The farmer or retailer should, in fact, be prepared by previous instructions to guard the milk supply from these sources of danger and call upon the authorities for an immediate inspection. To prevent great loss incident to these restrictions, they may be modified so as to utilize the milk after proper sterilization under the direction of the Health Department. The retailer should be duly registered and be required to furnish the health office with a list of customers. These lists should be arranged on the "index card system," so that the simultaneous occurrence of infectious diseases in a number of families supplied by the same milkman may be promptly discovered and the mischief checked.

There is nothing strained in these requirements, as good and sufficient reasons have been adduced, and by their enforcement we may hope to obtain such a standard of milk as will not only effect a decided reduction in infantile mortality, but will render the dissemination of infectious diseases through the milk supply a matter of history only. Until this is accomplished, we should patronize only such dealers as sell "certified milk," or subject the milk in pint bottles to pasteurization at a temperature of 155° F. for thirty minutes, and after cooling keep it on ice; this will not make bad milk good, but it will at least destroy its infectiousness.

George Martin Kober.

MILK SICKNESS.—The early settlers in the Middle West, or the region between the Alleghany Mountains and the Mississippi River north of Georgia and Alabama, suffered in their own persons and in their cattle from a severe and often fatal malady, called by the term which heads this paragraph. In cattle the affection was called "trembles," but its relation to the "milk sickness" of man was so close as to leave no doubt in the minds of either the physicians or the laity of those times that the two were one and the same disease.

In animals the first symptom noted was marked apathy; the animal stood apart from the herd, motionless with drooping head, and persistently refused to graze. Later a general tremor came on, its appearance being hastened by forced exercise of the animal, there was extreme thirst in most cases, and constipation was pronounced. Soon the animal lay down, respirations became less and less frequent, the extremities grew cold, the eyes glassy, and death usually occurred at the end of eight or ten days.

In man the symptoms were very similar. There was complete anorexia, nausea and vomiting were frequent, and constipation was absolute. The urine was clear and limpid, but reduced in amount despite the large quantities of water taken to quench the intolerable thirst. The pulse was weak and compressible; the temperature was usually below normal, but in exceptional cases might rise to 99° or 100° F.; there were never any chills, and the headache ushering in malarial and typhoid fevers was conspicuously absent.

Milk sickness was a very grave malady, and recovery seems to have been the exception, though not impossible. There was no specific treatment, but the best results were obtained by judicious stimulation and careful nursing.

As the disease is no longer recognized—whether because it has become extinct or because better diagnostic methods have corrected our nosology, it is difficult to say—it is impossible to determine what its true nature was. Indeed, many observers to-day question whether there really ever was a morbid entity such as that described under this name. In Volume V. of the first edition of this work Dr. William M. Beach, a pioneer physician in Central Ohio who had had a wide experience with "milk sickness," contributed an article on the disease, and to this we should refer readers who desire to learn more of the facts than are here detailed. This brief abstract of Dr. Beach's article is inserted in this place for purely historical reasons, the disappearance of the disease having rendered a more extensive treatment of the subject unnecessary.—[Abstract of article by *William M. Beach.*]

MILK, SUGAR OF.—SACCHARUM LACTIS. "($C_{12}H_{22}O_{11}+H_2O$). A peculiar, crystalline sugar, obtained from the whey of cow's milk by evaporation, and purified by recrystallization" (U. S. P.). Sugar of milk crystallizes in four-sided rhombic prisms. These are usually collected upon sticks or strings hung in the concentrated solution; thus are formed long rolls, three or four inches in diameter, the crystals densely massed and tapering to a point at the axis of the roll. Much of the sugar, however, is crystallized in pans and comes in fragments of large cakes, two or three inches in thickness. The following is the official description:

"White, hard, crystaline masses, yielding a white powder feeling gritty on the tongue, odorless, and having a faintly sweet taste. Permanent in the air.

"Soluble in about six parts of water at 15° C. (59° F.), and in one part of boiling water; insoluble in alcohol, ether, or chloroform.

"The aqueous solution of sugar of milk is neutral to litmus paper.

"On adding to a few cubic centimetres of a hot, saturated aqueous solution of sugar of milk an equal volume of sodium hydrate T. S., and gently warming, the liquid will turn yellow and brownish-red. On the further addition of a few drops of copper sulphate T. S., a brick-red precipitate will appear.

"If about 1 gm. of powdered sugar of milk be sprinkled upon about 5 c.c. of cold sulphuric acid contained in a flat-bottomed capsule, the acid may acquire a greenish or reddish but no brown or brownish-black color within half an hour (absence of *cane sugar*)."

The aqueous solution differs from that of ordinary sugar in being thin and not in the form of a syrup.

The very numerous uses of milk sugar in the pharmacy, in connection with other substances, as an excipient, makes it unusually important that it be kept fresh and pure. Its delicate and extensive use in the preparation of artificial milk for infants renders this caution still more important. The substance has no special physiological action, and its use in milk preparations will be found described under *Milk*. *Henry H. Rusby.*

MILLBORO SPRINGS.—Bath County, Virginia.

POST-OFFICE.—Millboro. Hotel and sanitarium.

ACCESS.—Viâ Chesapeake and Ohio Railroad to Millboro Depot, thence by carriage two miles to springs. The hotel is situated on a gently sloping eminence about two thousand feet above the level of the sea. The situation commands a fine vista of green fields, fertile valleys, lofty forest-capped hills, and in the distance the towering summits of the Alleghanies. The climate here is of the usual dry, bracing character of the Virginia

mountain region. The hotel is a comfortable, well-kept establishment, having a capacity of one hundred guests. Lawn tennis, croquet, bowling, riding, and driving are among the amusements offered. The Wallawhatoola River, half a mile distant, furnishes excellent bass fishing. There are several mineral springs here, the most important being the Sulphur and the Alkaline Springs. The following analysis of the former was made in 1891 by G. B. M. Zerr, chemist, of Staunton, Va.:

SULPHUR SPRING (MILLBORO'S SPRINGS).

ONE UNITED STATES GALLON CONTAINS:

Solids.	Grains.
Sodium hydrosulphate	3.34
Calcium sulphate	1.55
Potassium sulphate	.11
Sodium bicarbonate	4.27
Magnesium bicarbonate	1.65
Calcium bicarbonate	.54
Iron bicarbonate	Trace.
Alumina	.26
Sodium silicate	.89
Sodium chloride	.47
Aluminum phosphate	Trace.
Organic matter	.35
Total	13.43
Gases.	Cu. in.
Sulphureted hydrogen	1.08
Carbonic acid	6.94

This is an excellent water of the alkaline sulpho-carbonated variety. It possesses antacid, tonic, and mild diuretic properties, and will be found useful in the class of cases to which such waters are applicable. The alkaline spring was analyzed by Dr. Zerr in 1895. It is somewhat milder than the sulphur spring, but is also a very useful water in acid dyspepsia, enfeebled states of the digestion, etc. *James K. Crook.*

MINERAL ACIDS, TOXICOLOGY OF. See *Acids, etc.*

MINERAL ALKALIES, TOXICOLOGY OF.—The alkaline carbonates and hydrates of potassium and sodium act as corrosive poisons.

Potassium carbonate is a white, crystalline salt, alkaline and deliquescent. It dissolves readily in water, its solution effervescing readily on the addition of acids. It is used in commerce under the names of pearl ash and salt of tartar.

The pure sodium carbonate is crystalline, colorless, odorless, and transparent. It has a sharp, alkaline taste and an alkaline reaction. On exposure to dry air the crystals effloresce and fall into a white, opaque powder. This compound is met with in commerce as washing soda or sal soda and is much used in the household for cleaning purposes.

Both these carbonates are much less poisonous than the hydrates of the same elements and they are of no great interest to the toxicologist. Their poisonous dose is large and their effect like that of the hydrates though much less intense.

The hydrates of both sodium and potassium are found in commerce in the form of irregular lumps, a more or less fine powder, or in the form of sticks, yellowish-white or pure white in color, crystalline, and bitter. All forms of these hydrates absorb moisture readily to such an extent as to become liquid. They dissolve in water very quickly with the evolution of great heat, producing if pure a clear liquid. A solution of each containing about five per cent. of the hydrate is official in the United States Pharmacopœia.

In strong solution the hydrates act energetically on cotton or woollen fibre and on animal or vegetable tissues in general, causing them to soften and disintegrate. On metals also they act corrosively and so insoluble a material as glass is after a time affected by them.

Poisoning by these substances is the result of accident or from suicidal intent, their sharp and biting taste serving to protect from their homicidal administration.

The first sensation on taking either the solid compounds or their concentrated solution into the mouth is a most intense burning and biting pain. In case any of the material is swallowed this sensation extends throughout the œsophagus and stomach. Vomiting generally follows, the materials ejected being frothy in character, brown, tinged with blood or streaked with mucus, and strongly alkaline in reaction and soapy to the touch. Sometimes there is purging. The abdomen in the region of the stomach is extremely tender to the touch, and the act of vomiting causes excruciating pain. The surface of the body is cold and covered with perspiration; the pulse is quick but feeble.

In some fatal cases death follows within three hours, the patient dying from shock; but more often life is prolonged sometimes for months, death finally ensuing from starvation or from perforation of the stomach or the œsophagus and subsequent inflammation.

Forty grains of the hydrate have been known to cause death, though one-half ounce is usually regarded as the poisonous dose.

Treatment in cases of poisoning by the fixed alkalies consists in the administration of dilute acids like vinegar or lemon juice to neutralize the alkali, and afterward oily or mucilaginous drinks to cover the raw surfaces. No attempt should be made to use the stomach pump on account of the softened condition of the tissues.

Post-mortem examination in cases of sudden death from the action of alkalies shows corrosion of greater or less intensity and extent, depending on the strength of the solution swallowed and the time during which it acted on the tissues. Usually the mouth is found white, or intensely red or brown, its mucous membrane loosened in shreds. The tongue is swollen and reddened; the œsophagus much inflamed, and its lining membrane softened so as to be readily detached from the tissues below, sometimes in shreds, in a few instances as a complete cast. The lungs are sometimes found inflamed and gray or deep brown in spots where the alkali drawn into them has come in contact with the tissue. The stomach is reddened and its mucous coat loosened. The blood-vessels of the stomach are congested and the blood in them is dark-brown in color. The intestines are usually normal, but sometimes show marked signs of inflammation. In case of death after a considerable interval the chief characteristic is the severe constriction or scarred appearance of the œsophagus or the stomach. In one case reported the opening into the stomach hardly admitted a probe. The œsophagus has been found much distended above its constricted portion, the constriction appearing hardened and considerably scarred. Perforation has also been noted on post-mortem examination.

In case of a chemical investigation of the stomach contents in poisoning by mineral alkalies these materials are usually found acid in reaction, either from the antidotes administered during life or because the normal acids of the stomach juices have neutralized so much of the alkali as remains in the body. The investigation is further complicated by the fact that the salts of both potassium and sodium are normal to the tissues and exist in nearly all foods. The vomit, at an early stage of a case of this kind, is therefore the most satisfactory material for an investigation. Whatever the material it may be best extracted from the organic matter by dialyzing and then concentrating the liquid so obtained. If this liquid is alkaline, titration by decinormal sulphuric acid is advisable, as this gives a measure of the amount of alkali still existing. If the extract is acid, or in any case after neutralizing, add an excess of sulphuric acid, evaporate to dryness, and incinerate. The residue is then treated with hot water and filtered. The sulphuric acid is removed by barium chloride and the barium sulphate filtered out. The chlorides formed are treated with milk of lime for some time and then filtered. The filtrate is saturated with carbon dioxide, boiled, and the precipitate, if any, filtered out. The filtrate is evaporated to dryness after the addition of sulphuric acid and the ignited residue weighed. Whatever the salts in the original solution

this residue consists of sodium and potassium sulphate. After weighing, the residue is dissolved in water, platinum chloride solution is added in excess, and the mixture is evaporated to dryness on the water-bath. The residue is treated with eighty-per-cent. alcohol and the insoluble potassio-platinic chloride filtered out, and after thorough washing with alcohol it is dried and weighed. The weight of the platinum salt multiplied by 0.2309 represents the weight of caustic potash. The difference between the potash, calculated to sulphate, and the weight of the mixed residue of sulphates represents the sodium sulphate. *Herbert M. Hill.*

MINERAL HILL SPRINGS.—Grainger County, Tennessee.

POST-OFFICE.—Bean's Station. Hotel and sanitarium.

These springs are located in the Bean's Station Valley, near the foot of Clinch Mountain, ten miles from Morristown. The peculiar arrangement of the valleys, hills, and mountains gives rise to a cool, refreshing air current, always passing from north to south in the morning and from south to north in the afternoon. We are informed by Dr. W. J. Heacker, of Bean's Station, that as many as twelve varieties of mineral water are found near the hotel, among which are mentioned red, white, and black sulphur chalybeate, Epsom, and alum waters. No analyses appear to have been made. The accommodations of this resort appear to have been largely extended and improved. It is stated that many varieties of ills are benefited by the genial climate and a free use of the waters. *James K. Crook.*

MINERAL SPRINGS AND WATERS.—Geologically, all the waters which issue from the earth might be designated as mineral, but in the common acceptation the term refers only to those waters which are used for internal or external medical purposes in virtue of their chemical contents, or on account of their natural temperature. Such waters have been employed in the healing art through all ages from the earliest dawn of history to the present day. Like many other medicinal agents, mineral waters in former times, before their proper constitution was understood, were superstitiously invested with powers which we now know they never could have possessed. Some of the ancient notions regarding their healing virtues are still retained by credulous or ignorant persons, and this fact is duly utilized by enterprising promoters of certain springs to their own commercial advantage, but not to the benefit of enlightened and progressive therapeutics. Aside from disappointing the expectations of invalids, the absurd claims published in their circulars by unscrupulous proprietors of mineral springs have served to prejudice the minds of medical men, some of whom in our own country ignore this subject altogether, and are content to leave the whole matter of mineral hydrotherapeutics in the hands of persons having nothing more than a commercial interest in its extension. In Europe, however, these agents are justly regarded as a valuable addition to the armamentarium medicorum, and a study of their uses is held as an essential part of materia medica and therapeutics. The students of all the chief universities are instructed in their rational uses, and the status of mineral waters is altogether dignified and satisfactory. Even on this side of the Atlantic there are evidences that the regular profession is awakening to a proper appreciation of the potential value of these remedial adjuncts, which in our own fair land are found in greater profusion and variety than anywhere else on the globe. A spirit of scientific inquiry and investigation is superseding the lethargy and indifference of American practitioners. Many of our spas are already provided with properly equipped sanatoria and bath-houses, and the writer learns from a recent visit to some of our well-known mineral spring resorts that an increasing number of the valetudinarian visitors are taking the waters under medical supervision.

The writer is convinced by his own continued observations that American medical men of to-day are far better acquainted with the chemical composition and therapeutical possibilities of our own mineral waters than they were fifteen or twenty years ago. The alert Yankee will not forever allow the fruitful fields which surround him to lie fallow and undeveloped. The veil of ignorance and superstition which has shrouded the medicinal operation of mineral waters having been brushed aside, the plain fact is revealed that these substances exert their physiological action and therapeutical effects precisely as do other internal remedial agents. It is known to all that a mineral water containing the sulphate of soda or magnesia will act on the bowels. A bicarbonated alkaline water will quickly remove the symptoms of acid dyspepsia, while it requires no argument to show that a potent chalybeate will influence the manifestations of anæmia, at least as readily as will one of the artificial preparations of iron. These are examples of what we know about the therapeutics of mineral waters. But we have not yet learned why a very few grains of sulphated, magnesic, or sodic salt will give a laxative influence to a natural mineral water, and that the physiological effects of arsenic can be readily secured by the daily imbibition of a water containing far less than the usual pharmaceutical dosage. Nor are we at present able to explain why we cannot gain these same effects by artificially adding these substances to ordinary potable water. The progressive practitioner, however, while desirous of further light regarding these matters, will not deprive his patient of the advantage of knowledge well attested by clinical experience while awaiting an exact explanation of the *modus operandi* of his remedial agents. We are equally ignorant as to the precise action of a majority of our most highly prized artificial preparations.

Certain European mineral springs were known to be useful in the treatment of syphilis and its sequelæ many years before a chemical analysis showed them to possess a minute quantity of the iodides of potassium and sodium. Similarly, quinine was known to be useful in malarial affections a very long time before it was learned that malaria was a specific infectious disease, and that quinine was destructive of its pathogenic microbe. We are often obliged to avail ourselves of empirical knowledge until the scrutinizing eye of the experimental chemist or physiologist supplies us with rational explanations.

With the possible exception of the sulphated-saline group, mineral waters find their chief application in chronic diseases. The very fact of the ease with which they may be introduced into the system gives them a vast advantage in many obstinate and long-continued affections in which the gamut of pharmaceutical remedies has been run and the stomach of the weary patient rebels at more drugs. Waters have a very much better influence when consumed at their original source at the spa than when used from bottles, demijohns, etc., in the city. At the spring the patient has the added advantages of a change of scenery, surroundings, climate and food, and a temporary absence from the worries and cares of home and business. Many a long-standing and well-nigh hopeless case of chronic rheumatism, anæmia, dyspepsia, or hepatic disorder has been restored to a state of perfect or comparative good health by a timely sojourn at a proper mineral spring resort. There are numerous excellent commercial mineral waters which may be used advantageously at home, but the effects obtained cannot compare with those derived at the fountain-head.

The employment of baths or the external use of water belongs more properly to the domain of general hydrotherapeutics (*vide* p. 788, Vol. IV.). In this place we can only briefly refer to the action of mineral waters on the economy through the medium of the skin and to balneological procedures employed at mineral springs. The time was when special virtues were attributed to the external application of water the temperature of which had been raised by the interior heat of the earth. More advanced reasoning, however, has led to the conclusion that terrestrial heat imparts no more value to water as a bathing medium than heat secured through the art of

man, unless indeed we make allowance for the somewhat ambiguous influence of suggestion which may operate in occasional cases. Mineral waters, however, do acquire increased influence on the cutaneous investment of the body by reason of their impregnation with certain chemical ingredients—sulphureted hydrogen, chloride of sodium, etc. In recent years it has been taught that these ingredients affect the economy merely by their local stimulating or sedative action on the skin, and that under the ordinary circumstances of the bath there is very little if any interchange of constituents between the animal fluids and the water of the bath—in other words, that none of the contents of the water is absorbed into the blood. This view is set forth in all the late works on this subject. However, clinicians and physiologists like Wittich, Gutman, Cheruszwesky, and Walkenstein maintain that the skin is permeable to watery as well as to alcoholic solutions. It is claimed that absorption is carried on by the cutaneous blood-vessels and lymphatics, supplemented by the natural law of diffusion. The fact that the presence of iodine and bromine is speedily detected in the urine after bathing in certain waters, notably those of Mount Clemens, Mich., lends strong support to this view. It cannot be gainsaid that when the body is immersed in a mineral bath the skin separates two saline solutions of unequal density, *i.e.*, the blood serum and the water composing the bath. Thus, according to the physical law of osmosis and the ionic action and properties of molecules, equalization of the two fluids will be brought about, or at least attempted. Aside from this question, which we may regard as being still in abeyance, the fact must be borne in mind that water is a much more rapid conductor of heat than air, and it is well known that the human system tolerates changes of temperature in the latter to a much greater extent than in the former. While the air at 75° F. is too warm for comfort for most persons, a continued bath at that temperature becomes cold and depressing. Again, a bath at from 98° F. to 102° F. acts far more energetically than the atmosphere at the same temperature.

Classification of Mineral Waters.—The need of a satisfactory scheme of tabulation of the different varieties of mineral springs, both for descriptive and for therapeutical purposes, has long been felt by medical men, and various methods of classification have been proposed by writers on the subject. The author is convinced that the following scheme suggested originally by Dr. Albert C. Peale of the United States Geological Survey and elaborated and modified by himself is all that is needful for the purpose, and is sufficiently elastic to cover the analysis of any mineral water, whatever its source. Under this method the writer has classified all the mineral springs of the United States that have been subjected to analysis and has found it to meet the requirements in every case. All mineral waters are divided primarily into two great groups and are then treated precisely alike with reference to their chemical contents.

Group A. Cold (non-thermal) springs.
Group B. Thermal springs.

Class I. Alkaline	Sulphated. / Muriated.
Class II. Alkaline-saline	Sulphated. / Muriated.
Class III. Saline	Sulphated. / Muriated.
Class IV. Chalybeate	Alkaline. / Saline. / Sulphated. / Muriated.

Class V. Neutral or indifferent waters.

The existence or non-existence of gaseous contents may be shown thus:

1. Non-gaseous.
2. Carbonated or acidulous—containing carbonic acid gas.
3. Sulphureted—containing hydrogen sulphide, etc.

A combined solid and gaseous water may be referred to as alkaline-carbonated, saline-sulphureted, etc. Any classification must, from the nature of the case, be somewhat arbitrary. Nature herself is an evolution. Many analyses so shade into each other that it is difficult to draw hard-and-fast lines. But the above classification admits of a ready subdivision according to the predominant or most important constituents, as follows: Sodic, magnesic, bromic, arsenical, acid, aluminous, etc.

Under the alkaline springs are included all those which are characterized by the predominance of the alkaline carbonates; as the carbonates of the alkalies, the alkaline earths, and the alkaline metals. There are no absolutely pure alkaline springs; all contain saline ingredients just as all saline springs contain alkaline. Many also contain iron, and a large majority of the most celebrated alkaline springs contain also carbonic acid gas. This substance not only greatly increases the solvent power of water, but imparts to it a bright and piquant sparkle, a grateful, somewhat acidulous, pungent taste, and furthermore enhances its therapeutic properties in certain states. Nearly half the alkaline springs of the United States are calcic-alkaline, *i.e.*, they contain calcium carbonate or bicarbonate as a predominant ingredient. But nearly all contain also the carbonate or bicarbonate of sodium, potassium, magnesium, iron, and many also lithium.

Physiological Action.—The alkaline carbonated waters stimulate the action of the stomach, render the urine alkaline, increase its flow, and are to some extent diaphoretic. They are not purgative unless strongly combined with salines, and they have a tendency to lessen catarrhal discharges.

Therapeutics.—These waters form a very efficacious and speedy remedy in the treatment of acid dyspepsia and flatulence. Given before meals they stimulate the peptic glands, thus promoting the flow of gastric juice and aiding the appetite and digestion. Though not curative, they are useful in ameliorating some of the symptoms of chronic catarrh or gastritis and cancer of the stomach. Their diuretic tendency gives them a useful application in fevers, rheumatism, gout, diabetes, vesical irritation, etc. The habitual use of these waters tends to render the urine alkaline, and it is believed by many eminent medical authorities that those containing lithium arrest the formation and favor the disintegration and expulsion of uric-acid calculi, concretions, etc. When combined with salines, iron, etc., these waters acquire new virtues which will be later referred to. The following analysis of one of the Manitou Springs of Colorado, the Navajo, presents a good example of an alkaline-carbonated water:

One United States Gallon Contains:

Solids.	Grains.
Sodium chloride	23.79
Potassium sulphate	15.35
Sodium sulphate	10.93
Magnesium carbonate	16.04
Iron oxide	.02
Sodium carbonate	42.60
Lithium carbonate	.61
Calcium carbonate	69.33
Alumina	.10
Silica	2.46
Total solids	181.23

Free carbonic acid gas.

Among the better-known American alkaline springs are the following:

Bladon Springs, Alabama; Highland Springs, California; Perry Springs, Illinois; St. Louis Spring, Michigan; Londonderry Lithia Spring, New Hampshire; Glen Springs, New York; Buffalo Lithia Springs, Virginia; Waukesha Mineral Springs, Wisconsin.

Well-known European alkaline springs are as follows: Apollinaris Springs (Neuenahr), Rhenish Prussia; Fachingen, Germany; Weilbach, Hesse, Germany; Ems-on-the-Lahn (Kesselbrunnen), Germany; Obersalzbrunn, Silesia; and Holy Well, North Wales.

Alkaline-Saline Waters.—This class includes all those waters in which the purely alkaline ingredients and the salines are present in anything like equal quantities. For example, a water whose predominant constituents

are the carbonate of sodium and the chloride of sodium, the other ingredients being in smaller proportions, or comparatively unimportant, would be properly ranked as an alkaline-saline. If the sulphate of sodium or potassium were present in considerable quantities the water might properly be referred to as a sulphated alkaline-saline. The waters of the alkaline-saline class are among the most richly impregnated known. Many of the best in the world are found in the United States.

Physiological Action and Therapeutics.—The therapeutical effects of these waters are brought about by the simultaneous introduction into the system of a double or triple group of compounds somewhat differing in their individual influence, and each to some extent supplementing the action of the others. These waters are in the first place antacid *par excellence.* Their prime ingredients are essential to the processes of osmosis, combustion, digestion, and secretion. With the chloride of sodium the alkalies contribute to maintain the blood in the degree of viscosity necessary for the process of endosmosis and exosmosis. These waters thus possess all the virtues separately set forth as attaching to the alkaline and saline classes. Many of the muriated alkaline-salines exert a certain laxative influence, but those containing the sulphate of sodium or magnesium possess the advantage of more directly stimulating the emunctory action of the intestines, thus promoting the easy and painless removal of waste products from the system. These waters thus become useful in the various chronic disorders of the alimentary tract characterized by the symptoms of catarrh of the stomach, intestinal sluggishness, hepatic torpor, and constipation. They may also be expected to render good service in cases of biliary and urinary calculi, in uric acid sand and gravel, in chronic bladder and urinary disorders, and in gout and rheumatism. While perhaps not properly denominated curative, they undoubtedly in many cases favorably influence the course of chronic albuminuria and saccharine diabetes. Owing to their active influence on tissue metamorphosis, the stronger waters of this group must be used with great caution by cachectic and debilitated persons. It is especially with these waters that misguided laymen in the United States are in the habit of experimenting on their own persons, often converting an ordinary case of dyspepsia or debility into one of gravity and seriousness. Their habitual use should never be undertaken except on the advice of a physician. As a rule these waters are contraindicated in acute inflammatory disorders and in chronic inflammations having a tendency to acute exacerbations. They must be used guardedly in cases of atheromatous degeneration of the arteries, in aneurism of the greater vessels, and in all weakened or enfeebled states of the myocardium or great aorta. Following is an analysis of the Saratoga Vichy Spring, a good example of the alkaline-saline class of waters:

One United States Gallon Contains.

Solids.	Grains.
Sodium bicarbonate	82.87
Calcium bicarbonate	95.52
Magnesium bicarbonate	41.50
Strontium bicarbonate	Trace.
Lithium bicarbonate	1.76
Iron bicarbonate	.05
Barium bicarbonate	.59
Potassium sulphate	Trace.
Sodium phosphate	Trace.
Sodium biborate	Trace.
Sodium chloride	128.69
Potassium chloride	14.11
Sodium bromide	.99
Calcium fluoride	Trace.
Sodium iodide	Trace.
Alumina	.48
Silica	.76
Organic matter	Trace.
Total solids	367.32

Carbonic acid gas, 383.07 cubic inches.

Many of the other Saratoga Springs belong to this class. There are so many excellent springs of the alkaline-saline group in the United States that it seems almost invidious to mention examples of them. The following are fair representations: Allen Springs, El Paso de Rabbo Springs, and Litton Seltzer Springs, California; Bowden Lithia Springs, Georgia; the Idanha Spring at Soda Springs, Idaho; West Baden Springs, Indiana; Fry's Mineral Springs, Iowa; Waconda Mineral Springs, Kansas; Americanus Well, Michigan; Ballston Spa, New York; Wilhoit's Soda Spring, Oregon; Dixie Springs, Tennessee, and the Borland Mineral Well of West Virginia. The following are celebrated European alkaline-saline springs: Bilin, Bohemia (Josephs-Quelle); Contrexéville, Pavillon, France; Vals, France; Luhatschowitz, Moravia, and Selters, Nassau, Germany.

Saline Mineral Waters.—The chlorides and sulphates give character to the saline class of waters and often coexist in the same spring. As a rule, however, one or the other group of salts is so preponderant as to overshadow all other ingredients. These waters may therefore be further subdivided into (1) the muriated salines and (2) the sulphated salines.

The muriated salines gain their character from the presence of the chlorides, viz.: the chlorides of sodium, potassium, magnesium, lithium, and iron. The chloride of sodium is by far the most important as well as the most universal of these salts, being found in almost every mineral water, from mere traces to many thousand grains in the gallon.

Physiological Action.—We cannot in this place undertake an account of the various functions of the chloride of sodium in the system. Suffice it to say that it is one of the essential components of the body, being present in every structure except the teeth. It is one of the most important factors in the process of nutrition, and its withdrawal is at once keenly felt. In mineral waters the remaining chlorides are not as a rule present in large quantities and are relatively unimportant. The chloride of lithium is found in a few springs, but its quantity is usually too small to influence the properties of the water. The chloride of magnesium occurs frequently in muriated waters. It forms the bittern of salt works, and occurs in great quantities in the waters of the Dead Sea and in some of the brines of New York and Michigan. It acts mildly as a purgative, promoting the flow of bile and increasing the appetite. The chloride of potassium coexists in many springs with common salt, though in much smaller quantity. Its functions and distribution in the body appear to be quite similar to those of its sodium congener. The chloride of calcium, like the carbonate of calcium, is not evacuant, but in large doses may cause constipation. Its influence in uric-acid states is probably identical with that of the carbonate. The chloride of iron is often a valuable ingredient of chalybeate waters.

When taken into the stomach in therapeutic doses the muriated saline or chloride of sodium waters cause an increase in the flow of gastric juice, bile, pancreatic juice, and intestinal fluid, promote the appetite, and aid in the process of digestion. They have a mildly aperient effect and exert an antiseptic influence on the intestinal mucous membrane, tending to prevent putrefactive changes. The increased quantity of urea excreted shows that they promote tissue metamorphosis. The bronchial mucous secretion is also increased.

Therapeutics.—In virtue of their physiological action the muriated sodic waters possess a valuable application in gastric, hepatic, and intestinal disorders. It would be difficult to mention a chronic affection involving the stomach, liver, or intestinal tract in which one of the chlorinated salines could not at some stage be beneficially exhibited, and their good effects are often greatly enhanced by the presence of valuable alkaline ingredients as well as iron. Herman Weber prefers them even to the bitter or sulphated saline waters in the portal congestion of thin or spare persons, in whom further reduction of weight is to be avoided. Their special application, however, is to be found in atonic dyspepsia, insufficiency of the digestive fluids giving rise to dry scybalous stools, a furred tongue, disagreeable taste in the mouth, loss of

appetite, hebetude, and malaise. In the "rocky" state following alcoholic excesses a copious draught of a potent carbonated and muriated saline water on rising will do much to restore tone and vigor to the gastro-intestinal tract and liver and assist no little in clearing up the befuddled functions of the central nervous system. Small repeated doses of the stronger alkaline-saline with ferruginous properties are of undoubted value in chronic broncho-pulmonary affections attended by a tenacious scanty expectoration and much debility. The strong carbonated brines are much resorted to at some spas, for their local effects; they are employed in the Schott treatment at Nauheim.

The following analysis of the Livingston Artesian Well of Alabama represents the make-up of a moderately strong muriated saline water:

ONE UNITED STATES GALLON CONTAINS:

Solids.	Grains.
Sodium chloride	295.43
Potassium chloride	.33
Calcium chloride	2.98
Magnesium chloride	1.84
Strontium chloride	Trace.
Iron perchloride	.19
Sodium bromide	.98
Iron bicarbonate	.20
Magnesium bicarbonate	2.32
Calcium bicarbonate	7.14
Silicic acid and silicates	1.14
Total	312.55
Gases.	**Cu. in.**
Free carbonic-acid gas (in solution)	21.47
Carbonic acid in combination as carbonates	9.32

In this class the United States possesses a large number of the best springs known. We have space to refer to but a few examples:

Byron Springs, Eureka Springs, and Calistoga Springs, California; Magnetic Mineral Springs, Indiana; Geuda Springs, Kansas; Upper Blue Lick Springs, Kentucky; Clark's Red Cross Mineral Springs, Mount Clemens Springs, and St. Clair Springs, Michigan; Sweet Springs (Akesion Spring) and Blue Lick Springs, Missouri; Glen Springs (Neptune), New York; Wasatka Mineral Spring, Utah; Parker Mineral Springs, Pennsylvania; Addison Sulphur Springs, West Virginia, and Sheboygan Mineral Well, Wisconsin.

The following well-known European springs are of this variety: Cheltenham and Harrowgate, England; Homburg (Elizabeth-Brunnen) and Kreuznach (Oranien-Quelle), and Wiesbaden, Germany; and Barèges (Boncheries), Hautes-Pyrenées, France.

THE SULPHATED SALINE WATERS.—The sulphated saline or purgative group of waters are characterized by the presence of the sulphate of magnesia (Epsom salt) or the sulphate of soda (Glauber's salt). These waters usually contain also the sulphate of calcium, sometimes the sulphate of iron, and frequently sulphureted hydrogen. The sulphate of magnesia is exceedingly soluble and is the important constituent of the so-called bitter-waters. The sulphate of sodium, which is also bitter and rather nauseous to the palate, is likewise very soluble and in variable quantities always coexists in mineral waters with the former salt.

Physiological Action.—Both these salts are laxative or purgative according to the dose taken. They act by promoting the process of endosmosis and exosmosis, thus abstracting the watery elements of the blood and increasing intestinal secretion. The action of Epsom salt appears to be limited chiefly to the intestinal glands, but the observations of Rutherford and Vignal show that the sulphate of sodium is also a valuable hepatic stimulant. Both salts are diuretic. The sulphates of calcium and potassium are of secondary importance in mineral waters.

Therapeutics.—It is in disordered conditions of the alimentary tract and liver, with the concomitant symptom of constipation, that the best effects of the sulphated waters are shown. In sluggish conditions of the liver characterized by yellowness of the conjunctivæ, a sallow countenance, coating of the tongue, and hemorrhoids, these waters are speedily beneficial. In eliminating chronic malarial and syphilitic infections from the system as well as in expelling lead, mercury, and other metallic poisons, they furnish an important and useful adjunct to other remedial measures. The sulphated waters are also of considerable value in promoting the absorption of pleuritic and peritoneal transudations. A small early morning daily dose of one of the stronger members of this group can be confidently relied upon as a valuable aid to other therapeutic procedures in œdema of the lower extremities and beginning general anasarca. On account of their accelerating influence in metabolism these waters are prescribed with advantage in cases of corpulency and fatty infiltration. The value of a brisk saline will be generally acknowledged in overcoming the disgreeable results of a heavy dinner accompanied with much wine. These waters must be used cautiously in cases of extreme anæmia or great debility; the range of usefulness of sulphated saline waters is materially broadened when they contain muriated saline and alkaline ingredients. The following analysis is of the American Carlsbad Spring of Washington County, Illinois:

ONE UNITED STATES GALLON CONTAINS:

Solids.	Grains.
Magnesium sulphate	103.70
Sodium sulphate	53.00
Calcium sulphate	65.80
Sodium carbonate	10.00
Sodium chloride	27.40
Total	259.90

Carbonic acid gas not determined.

Other American sulphated saline springs are as follows: Crab Orchard Springs, Kentucky; B. B. Mineral Spring, Missouri; Tate Springs and Montvale Springs, Tennessee; Gibson Mineral Wells and Wootan Wells, Texas; Fort Crawford Mineral Well, Minnesota; Catoosa Springs, Georgia; Blue Ridge and Yellow Sulphur Springs, Virginia; Salt Sulphur Springs, West Virginia; Cooper's Wells, Mississippi, and Manhattan Artesian Well, Kansas.

Many of the Saratoga waters are excellent mild purgatives, but are bicarbonated magnesic and sodic, and not sulphated. It is only in the class of sulphated salines that the waters of the United States are somewhat inferior, on the whole, to those of Europe.

Among the well-known foreign purgative waters are the following: Carabaña Mineral Spring and the Rubinat Springs of Spain; the Hunyadi Janos Wells and the Apenta Springs of Hungary; the Püllna, Seidlitz, and Friedrichshall of Germany.

CHALYBEATE WATERS.—Within the borders of the United States have been found the most richly mineralized iron waters known to the analytical chemist. Iron is perhaps most often found in mineral springs in the form of the bicarbonate—although many analyses show the sulphate, some the oxide, and still others the chloride. The bicarbonated chalybeate waters are usually most valuable for internal administration. Not only does carbonic acid increase the solubility of the iron, but it disguises the otherwise astringent and ferruginous taste and aids in its speedy absorption and assimilation.

Physiological Action.—Clinical experience shows that the chalybeate waters cause an increase in the appetite, a return of normal color, a gain in weight and strength, and a general improvement in the bodily functions. Investigations with the hæmoglobinometer have further proved that the deficiency of the coloring matter of the blood observed in anæmic states may be speedily made up by the administration of a properly selected chalybeate water. As iron in many of its pharmaceutical forms frequently disagrees with the stomach, we have in natural mineral waters a safe and pleasant means of introducing it into the system. Nor is it essential that the element be present in large quantity. A chalybeate water containing not more than one grain of a salt of the

metal in a gallon will promptly show its influence in the returning color of the face and the increased tone and vigor of the system.

Therapeutics.—The indications for the use of iron waters are numerous. It may be said that they serve a useful purpose in almost all debilitated states of the system accompanied by a loss in the hæmoglobin of the blood. In tardy convalescence from acute diseases, in the anæmic state resulting from a severe operation or difficult confinement, in all forms of hemorrhage not due to fulness of the vessels or fragility of their coats, in amenorrhœa when due to chlorosis, in the debilitated catarrhs of the uterus and vaginal mucous membrane, and in the various cachexias, the chalybeate waters supply us with a useful adjunct to the ordinary methods of treatment. Iron waters, like the iron pharmaceutical preparations, must, of course, be used guardedly in cases in which there is reason to suspect the integrity of the blood-vessels. They are as a rule contraindicated in vertigo, in congestive headaches, and should not as a rule be prescribed to stout, red-faced, plethoric persons. The following is an analysis of the "Round" Spring at Aurora Springs, Missouri. It is an almost pure chalybeate:

ONE UNITED STATES GALLON CONTAINS:

Solids.	Grains.
Ferrous carbonate	5.13
Ferrous oxide	.93
Magnesium chloride	6.95
Sodium chloride	4.01
Calcium sulphate	2.42
Lithia	1.43
Total	20.87

Other American chalybeates are as follows: Matchless Mineral Wells, Alabama; Arkansas Lithia Springs, Arkansas; Pacific Congress Springs, Fulton Wells, and Pagoda Spring, California; Puller Springs, Georgia; Indian Springs, Indiana; White Sulphur Springs, Iowa; Topeka Mineral Wells, Kansas; Addison Springs, Maine; Mardella Springs, Maryland; Brown's Wells, Mississippi; Londonderry Lithia Spring, Vermont; Heath House Spring, New Jersey; Adirondack Mineral Spring and Oak Orchard Acid Spring, New York (all the Saratoga Springs of New York also contain iron, the Putnam having over seven grains per United States gallon); Gaylord and Gulick Springs, Pennsylvania; Austin Springs, Tennessee; Overall Mineral Wells, Texas; Bath Alum and Rock Enon Springs, Virginia.

The following are European chalybeate waters: Pyrmont, Waldeck, Germany (Trink-Brunnen), and Schwalbach, Nassau, Germany, (Stahl-Brunnen); Tunbridge Wells, England; Spa (Ponhon), Liège, Belgium; and St. Moritz (Grande Source), Grisons, Switzerland.

THERMAL AND SULPHURETED WATERS.—A thermal spring is one whose temperature is higher than the average annual temperature of the surrounding atmosphere. For practical purposes it is customary to classify all springs above 70° F. as thermal and those below 70° F. as cold. Thermal springs having a temperature between 70° and 98° are designated as warm; those above 98° F. as hot. As thermal and sulphureted springs have much in common they may be treated collectively. Hydrogen sulphide gives character to the sulphureted class of waters, and is an important constituent of many of our most valuable thermal springs as well as of a large number of cold springs. It imparts to water a peculiar odor of decayed eggs, which at some springs may be appreciated at a considerable distance with a favoring wind. Hot sulphureted springs are most frequently observed in mountainous or volcanic districts; they contain sulphates of a number of the elements and occasionally sulphides and sulphuric acid.

Physiological Action.—The activity of sulphureted hydrogen when taken into the stomach admits of doubt. Valuable alterative effects have been attributed to it, but it is probable that the older writers over-estimated the influence of this substance on the secretions. It seems fairly well established that it promotes to some extent the activity of the skin, kidney, and bowels. Many of the hot sulphureted waters, even though but lightly mineralized, will secure a speedy evacuation of the bowels if taken fresh from the spring before breakfast.

Therapeutics.—The internal use of these waters is highly advocated by medical practitioners of experience in the treatment of gout, rheumatism, chronic synovitis, white swelling, and many of the varieties of skin troubles. Some of the sulphur springs have long been celebrated in the treatment of chronic malarial infection, accompanied by an enlarged spleen and liver and in hepatic congestion, abdominal plethora, and hemorrhoids. They are highly recommended by European practitioners in chronic female pelvic disorders of inflammatory origin. It is quite possible, however, that many of our well-known sulphur springs owe their celebrity more to coexisting ingredients than to hydrogen sulphide. Thermal and sulphureted waters are largely employed for bathing purposes, and we may here consider some points in connection with mineral water baths. It cannot be disputed that many forms of chronic complaints are treated successfully by a systematic course of bathing at a spa, after having resisted all other therapeutic methods. We may properly attribute at least a part of this fortunate outcome to the stricter régime observed at the springs, to the greater willingness of the patient to adhere to rigid instructions than at home, and to the favorable circumstances of environment, climate, scenery, absence of home cares, etc. It is but fair, however, to attribute some portion of the good result to the stimulating character of the waters and possibly to the absorption of some of the ingredients. Sulphureted hydrogen waters are widely used for bathing at springs, and are recommended for many diseased conditions, notably tertiary syphilis, chronic rheumatism and rheumatoid arthritis, stiff joints, old glandular swellings, squamous skin diseases, the effects of chronic malarial toxæmia, portal congestion, metallic poisoning, etc. It is not, however, possible to trace in a scientifically satisfactory way the undoubted influence of sulphureted waters to the gas itself, to which spring managers as well as many physicians have attached so much importance.

The following is the analysis of the Santa Barbara Hot Spring, of California, the composition of a thermal sulphureted water plentifully charged also with carbonic-acid gas:

ONE UNITED STATES GALLON CONTAINS:

Solids.	Grains.
Sodium chloride	1.74
Sodium carbonate	2.17
Sodium sulphate	14.92
Magnesium sulphate	7.75
Calcium sulphate	6.03
Aluminum	2.90
Arsenic	Trace.
Silica	1.18
Sulphuric acid	Trace.
Organic matter	Trace.
Total solids	36.69
Gases.	**Cu. in.**
Free carbonic acid	19.14
Sulphureted hydrogen	9.16

Among the many excellent American thermal springs several of which are also sulphureted may be mentioned the following: Arrow-Head Hot Springs, El Paso de Roble Hot Springs, Harbin Hot Sulphur Springs, and Skaggs Hot Springs, California; Arkansas Hot Springs, Arkansas; Glenwood Springs and Hot Sulphur Springs, Colorado; Warm Springs, Georgia; Ferris Hot Springs and Hunter's Hot Springs, Montana; Walley's Hot Springs, Nevada; Hudson Hot Springs, and Las Vegas Hot Springs, New Mexico; North Carolina Hot Springs, North Carolina; Belknap Hot Springs, Oregon; South Dakota Hot Springs, South Dakota; Terrell Hot Medicinal Well, Texas; Beck's Hot Springs, and Utah Hot Springs, Utah; Hot and Warm Springs, Virginia.

Numerous cold sulphur springs are found in all parts of the United States. Richfield Springs, of New York,

and Greenbrier White Sulphur Springs, of West Virginia, are familiar examples.

The following well-known European spas possess celebrated thermal springs: Aix-la-Chapelle, Baden Baden, Ems, Nauheim and Wiesbaden, Germany; Aix-les-Bains, Bagnère-de-Luchon, La (Reine) and Bourbonne, Haute-Marne, France; Carlsbad and Töplitz, Bohemia; Gastein, Salsburg, Austria; Leuk, Switzerland, and Bath, England.

Neutral or indifferent waters of which many well-known examples are found in the American markets cannot, properly speaking, be classified as mineral waters as they contain, as a rule, a smaller percentage of mineral ingredients than is to be found in the potable water supplied to most of our cities. The use of these waters is not to be discouraged, however. Practically without exception they are pure and wholesome, and entirely free from bacterial contamination. There are not wanting numerous reputable medical men who attach a distinct medicinal value to some of these excellent but finely attenuated beverages.

There are a number of well-known springs, some of which are not mentioned in any of the above groups, which owe their virtues to some one particular ingredient. Among these may be mentioned the arsenical, lithia, acid, and iodo-bromated waters.

James K. Crook.

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MINI-NI-YAN SPRINGS.—Kendall County, Illinois.

Post-Office.—Bristol. Accommodations at private residences.

The village of Bristol is located on the main line of the Chicago, Burlington, and Quincy Railroad, forty-seven miles from Chicago. Five springs exist within a short distance of each other, but only two have been used medicinally. No. 5, the principal one (an artesian spring), yields 10,000 gallons a day, which can be increased to 100,000 by pumping. Two analyses have been made, the first by the chemist of the State University and the second by the chemist of the Chicago, Burlington, and Quincy Railroad. Both of the analyses have been lost. We are informed by Mr. G. G. Hunt, the proprietor, that the water contains about ninety-two grains of solid matter per United States gallon, consisting principally of the carbonates of sodium, magnesium, iron, calcium, and lithium, and the phosphate of lithium. It is also said to contain small but perceptible quantities of iodine, bromine, and manganese. The water is said to exert a very favorable influence in cases of nervousness, headache, insomnia, and functional disorders of the liver and kidneys. In the form of a hot bath it has been found decidedly efficacious in painful swellings of the joints, glandular enlargements, and rheumatic and gouty conditions. *James K. Crook.*

MINNEQUA SPRINGS.—Bradford County, Pennsylvania.

Post-Office.—Minnequa. Hotel.

Access.—Viâ Northern Central Railroad, a connection of the Pennsylvania Railroad, forty-one miles north of Williamsport, Pa., and thirty-seven miles south of Elmira, New York.

The Minnequa Springs are located in a rich farming and dairy country at an altitude of 1,500 feet above the Atlantic Ocean. The pure mountain air, romantic scenery, delightful drives, and shaded walks afford abundant opportunities for the enjoyment of outdoor life. The location is within easy driving distance of Mount Pisga, the highest point in Pennsylvania. The hotel at Minnequa is a commodious structure, containing ten thousand feet of wide verandas, and is well fitted with steam heat, electric bells, elevators, etc. In the building the visitor will find a post-office, telegraph office, and railroad ticket office. Many well-known New York and Philadelphia families have their summer homes in the neighborhood. The mineral springs are three in number, and yield about six hundred gallons per hour. The waters have been examined by several chemists, the following most recent analysis having been made by Charles M. Cresson, M.D., of Philadelphia:

One United States Gallon Contains:

Solids.	Grains.
Calcium	0.99
Magnesium	.20
Sodium	.72
Lithium	Trace.
Aluminum	.12
Iron	Trace.
Manganese	.23
Chlorine	.14
Silica	.70
Zinc	.03
Carbonic acid	2.05
Boric acid	2.13
Oxygen (with silicates)	.14
Loss	.15
Total	7.60

It will be observed that the terms of this analysis are expressed in the radicals found. The combinations would be made up of carbonates and chlorides. An analysis of one of the springs made by Dr. Gregg some years ago showed the presence of sulphate of potassium and hydrogen sulphide. The waters of these springs have been used, for medicinal purposes, since the early settlement of this region. They are mildly antacid, tonic, and diuretic in their action. Owing to the presence of zinc and manganese they have been recommended by some physicians in the treatment of certain nervous affections, including epilepsy and chorea. *James K. Crook.*

MISTLETOE. See *Loranthaceæ.*

MITOSIS. See *Cell.*

MOLASSES. See *Sugar.*

MOLLIN is a potassium soap containing about thirty per cent. of glycerin and fifteen per cent. of free fat in emulsified condition. It is a smooth, soft, yellowish-white, unctuous material, which is miscible with water so that it may be washed off the skin.

Carbolated and creolinated mollin and mollichthyolin are mixtures of mollin with carbolic acid, creolin, and ichthyol, respectively. *W. A. Bastedo.*

MOLLUSCUM CONTAGIOSUM.—Despite the belief, shared at one period by most teachers of dermatology, that this disease is not contagious, the name given by Bateman has clung to it, and is to-day more appropriate than others which have been suggested, such as sebaceum, epitheliale, verrucosum, epithelioma contagiosum, and acné varioliforme. The last-mentioned designation, given it by Bazin, should be definitely dropped because of the other acne varioliformis, an affection which has been generally accepted as best designated in this way.

Although the lesions are usually of small size and distributed chiefly over the face, neck, chest, and genitals, it is well to bear in mind that a single tumor may at times attain the size of a large orange, and that the lesions may, from their size and long duration in unusual situations, be mistaken for malignant growths. I have removed from the cheek of a young girl a lesion which had existed singly and with so considerable an amount of surrounding swelling that sarcoma had been suspected. Balzer and Alquier[1] report a slowly increasing papillomatous tumor of the sole of the foot in a boy,

which was excised after seven or eight months, and was found to be a molluscum contagiosum.

Upon the penis I have seen a filbert-sized growth which had been mistaken for an unusual form of chancre. Occasionally the lesions are so abundant as to be scattered over almost the entire body, especially when some pruritic affection coexists, favoring dissemination by reason of scratching. Such a condition I have seen in prurigo, and the distinction must here be carefully made between the skin-colored, intradermic, firm lesions of prurigo and the "pearl-button"-like, sessile, pinkish and softer molluscum lesions.

Hallopeau[2] speaks of lesions so closely aggregated that they resembled bunches of grapes, and other groups suggesting frambœsiform nævi. I believe I was the first to call attention to lesions upon the mucous surface of the lips. Abraham[3] records the presence of lesions in the mouth resembling large patches of leucoplakia, which were found on close inspection to be made up of numerous small papules merged together. This condition, which I have never seen, might be confounded with an affection of the lips and buccal membrane often observed by myself, and to which Fordyce has directed attention.[4]

Description of the Lesion.—Recent lesions are miliary in size and are to be discovered only upon close observation, and better with the aid of a lens. When they are a few weeks old they have somewhat the appearance of milium, but the color is more pinkish. They are more elevated and have rather the appearance of waxy warts, but differ from the latter in showing a central opening through which slight lateral pressure will cause a milky fluid or a soft cheesy material to exude. While the base is usually somewhat constricted, this is not always the case, and, as has been already stated, lesions which attain a great size may be almost wholly intra- or subcutaneous. There are usually no subjective symptoms, aside from those occasioned by secondary inflammatory processes.

There is at the present day no doubt of the transmissibility of the affection, clinical data having been sufficiently substantiated by experimental inoculation.

Diagnosis.—While this is a very simple matter after one case has been attentively observed, my experience teaches that not only is the diagnosis rarely made by students in the clinic, but that practitioners frequently fail to recognize the condition or let it pass as something unworthy of notice, thus favoring the spread in the family, school, or institution. It is to be distinguished chiefly from molluscum fibrosum, the tumors of which are much firmer and, in addition, lack the central opening and the semi-solid contents.

The tumors of M. fibrosum are deeply embedded in the skin and tissues beneath it. They are much more common upon other regions of the body than the face, and are often found associated with pendulous masses. At times there projects from the central portion of an epithelial molluscum a horny mass. Pathological anatomists are now inclined to place the origin of these soft, semiglobular growths in that portion of the rete mucosum which is continuous with the sebaceous glands, or which dips down between the papillæ. The view formerly entertained, that the tumors originated in the sebaceous follicles, is still held by some, who look upon them as a transformation of the gland itself into horny amorphous structure surrounded by thickened walls. At times changes can be made out at or near the neck or root of the hair. There seems to be no question that the affection should be classed with new growths.

Etiology.—There is abundant reason for the belief that in time the parasitic nature of the disease will be established. A tender and delicate skin; a cutaneous surface subjected to continuous perspiration; the presence of a pruritic affection—all these are factors which favor the development and spread of the disease. The lesions may exist in large numbers upon the penis, scrotum, and female genitals, especially in young subjects, without reference to venery, although sexual contact favors dissemination.

Pathological Anatomy.—The tumors are made up of diverging lobules opening into a central cavity.

Delicate fibrous partitions separate these lobules, and a fibrous capsule envelops the whole. When the contents are squeezed out of the external capsule, the appearance of the extruded mass is that of a diminutive brain or of an enlarged sebaceous gland. The separate lobules are lined with palisade cells continuous with those of the adjacent rete. They are filled with nucleated epithelium, cuboidal or rounded. In the changes which are taking place in these cells, the outer portion

Fig. 3360.—Molluscum Contagiosum. (From Dr. George H. Fox, *American Journal of Obstetrics.*)

seems to show numerous granules of kerato-hyalin. Cornification rapidly takes place, producing a capsular covering for the cell. The interior changes are similar to those of colloid or amyloid degeneration.

Molluscous corpuscles or bodies, which have long been recognized, are oval-shaped, homogeneous in their composition, and enclosed in a horny capsule. It is the accumulation of these bodies in the central opening of the molluscous tumor which forms the milky fluid which is noticed when the latter is pressed upon.

These peculiar double-contoured, globular elements resembling psorosperms, and thought at different times to be allied to them, were believed by Virchow to be degenerated epithelium. This eminent scientist believed the molluscum growth itself to be a lobulated glandular epithelioma.

Boeck, who found a strong resemblance between these tumors and sebaceous glands, noted evidences of vascularity in them. In the semi-fluid contents he discovered, beside the molluscum bodies, epidermic cells with peculiar formation, often without nuclei and with sharply defined outline. He believed that the first type of oval, non-nucleated body developed from the second. He claimed that the bodies arose from a change in the protoplasm beginning next to the nucleus. No fat is to be detected by chemical or physiological tests, and these tests also show that these bodies are not amyloid in their composition.

Renaut regards the process as a hyaline degeneration in the perinuclear zone of the rete cells. Geber held the same view in regard to their origin from a hyaline degen-

eration of a hyperplastic growth in the interpapillary rete cells.

Török and Tommasoli, while strong believers in contagion, were unable to obtain cultures from the contents of the little tumors. They found, also, that the strongest acids and alkalies had little or no effect upon these contents. In their opinion these bodies are the result of colloid degeneration.

Pick gives an instance of successful inoculation and ranges himself amongst the believers in the parasitic theory.

Neisser believes that the bodies are parasitic because no products of degeneration look like them; because analogous bodies may be observed in other psorospermia; because the cells, which are without analogy in human pathology, are met with in a truly contagious and inoculable process; and because the conditions existing in this tumor, as compared with those of other epithelial new growths, are unique. As regards this latter point it may be said that we are dealing with a new growth whose cells are in part only affected with degeneration, whose nucleus, although pushed to one side, remains always intact, and whose mode of growth is quite different from that which occurs in carcinoma and all other epithelial hyperplasias.

Bender calls attention to another point of difference from other epidermal new growths, viz., that whenever mitosis occurs it is limited to the palisade layer. He believes also that the molluscum body is a parasite because it takes the aniline gentian-violet stain as do other parasites; because it is so sharply separated from cell protoplasm; and, finally, because the large number and the great variety in the shapes of these bodies in a given cell point only to segmentations of a parasite.

Drs. White and Robey,[5] of Boston, find that the new growth is formed by hyperplasia of the rete cells which push the mass downward and outward, producing a globular tumor. They fail to find any bodies which by any possibility they can call gregarinæ, or anything like a division of a nucleolus. The so-called molluscum bodies are, in their opinion, simply keratin, identical with the horny layer, except in the shape of the individual cells. Dr. Robey's bacteriological study resulted in finding only the staphylococcus epidermidis albus of Welch. The result, then, of this most recent careful investigation leads to the conclusion that, although a parasite probably exists, it has thus far not been successfully demonstrated, and that "the change is not a colloid or hyaline degeneration, but rather an extraordinary metamorphosis of rete cells into keratin."

Treatment.—Internal treatment is never required, and while it may be possible at times to remove the lesions with applications of ammoniated mercury, sulphur, or resorcin ointments, or by the free application of green soap, still the simpler and easier method is to scoop out each separate lesion with a curette, and wash the parts with bichloride solution (1 to 500–1 to 1,000). The contents of the lesions may be squeezed out readily between the finger nails of opposite hands, preferably the thumb nails, but this makes the operator liable to infection, and I have been called upon to treat an ophthalmologist for a lesion upon the thumb which he had acquired in this way.

Unless the lesion is large or of long standing and wart-like, removal by the knife, scissors, or ligature, or by the application of a caustic after curetting, is not called for. Electrolysis may be used, but is seldom required. After the removal with the scissors or knife there is apt to be free bleeding from the base, just as there is after the removal of warts, to which mollusca bear such similarity. The silver stick may be employed with the object of checking annoying hemorrhage.

Charles Warrenne Allen.

[1] Annales de Dermat. et de Syph., No. 4, 1900.
[2] Journ. des Maladies Cutanées et Syphilitiques, July, 1899.
[3] Trans. British Journal of Dermatology, December, 1899.
[4] Trans. Amer. Dermat. Assn., 1898.
[5] Journal of Medical Research, vol. vii., No. 3, April, 1902.

MOLLUSCUM FIBROSUM.—This affection has been variously designated as M. simplex, M. pendulum, M. areolo-fibrosum, M. albuminosum, and fibroma molluscum. It is a chronic hypertrophic affection of the skin which manifests itself in the form of multiple soft, sessile, or pendulous tumors; rarely in that of a single,

Fig. 3361.—Generalized Fibroma Molluscum. (After Wigglesworth.)

pendulous mass of connective-tissue structure. The two varieties are often found in association; the patient presenting perhaps one or more large pendulous masses from the side of the head, neck, or trunk, with smaller lesions scattered over other surfaces.

The lesions are solid or semi-solid, more or less rounded or elongated growths varying from the size of a pea to that of a tumor weighing perhaps several pounds. The younger lesions occur as subdermal nodules, while those of long standing may hang by a thin pedicle. Pear-shaped lesions, hanging, as it were, by the stem, are not

uncommon. The color is that of the natural integument, and the skin covering is usually soft and supple, though perhaps marked with blood-vessels and enlarged openings of sebaceous glands. Subjective symptoms are usually wanting.

When grasped between the fingers, the tumors are found to be firmly elastic, soft, lobulated, somewhat like a fatty tumor, or they present the feel of a cord-like body which can be rolled under the finger between the folds of skin. When they have existed for a long time, degenerative changes, of a fatty, calcareous, or (very rarely) bony nature, may occur. While they may exist from birth, in most instances they are of later development. They begin at times as a slight uplifting of the skin over a circumscribed rounded area. Pressure upon this pinkish soft spot gives the impression of an atrophy or thinning of the skin beneath, or of a pitting, in the deeper central part of which the raised area may be invaginated. When tumors have attained some size they may present to the touch the sensation of containing bundles of fibres. As a rule, the younger the subject the softer the lesions, those of old age being usually firm. Besides the circumscribed and disseminated forms of fibroma, we have closely allied conditions of pachydermatocele (dermatolysis, chalazodermia), which may occur as a sequence or as a condition *per se*, or it may result from states other than that of M. fibrosum. Pendulous masses of thickened skin or even areas showing no marked thickening are endowed with such elasticity that they may be drawn far away from the body's surface, and when released they spring back into place. This condition is not to be confounded with the changes which occur in senility, pregnancy, etc. While it is usually congenital, it may be, though rarely, an acquired state.

Diagnosis.—The occurrence of protruding and pendulous tumors, pink or flesh-colored, occasionally reddish or brownish, is not to be confounded with multiple sarcoma which has a violaceous or more markedly red hue, and the lesions of which are not pedunculated. Moreover, sarcoma shows a tendency to ulceration, and other evidences of malignancy are not long absent. Sebaceous cysts, which if present in large numbers simulate the disease, contain a soft material which can be pressed out. Multiple fatty tumors (a comparatively rare condition) are characterized by the peculiar lobulation of these growths and by being flatter and usually much broader at the base. Leprosy is to be excluded by its general constitutional effects, by the tendency of the lesions to become confluent, and by their peculiar brown and reddish hues and at times waxy appearance. Molluscum contagiosum is the least likely of the affections enumerated to be confounded with it. As a rule, the lesions in generalized molluscum contagiosum are decidedly smaller, and close inspection reveals the central opening, while pressure causes at least a milky drop to ooze from it. Neuroma is distinguished by the pain attending the tumors, and gummata by the evidences of constitutional lues. Verrucæ have their characteristic warty summit and practically never occur in such a generalized way.

Pathology.—While there is still a question of the exact tissue in which the growth originates, some cling to Rokitansky's view of its origin being in the connective tissue of the corium, and some hold, with Virchow and Kaposi, that it starts around the fatty tissue or about the hair follicles, as Fogg believed. It is now generally accepted that the connective-tissue elements undergo a transformation into bundles of fibres and that fibrous tissue predominates in the outer, while a protoplasmic mass makes up the inner portion of the tumor, which is bound down by its pedicle to the subcutaneous tissue. Incision shows an encapsulated fibrous mass of peculiar whiteness. The central portion is soft and pulpy, and on pressure a small amount of yellowish fluid exudes. Old tumors show dense fibrous tissue and at times are quite vascular about the base. Newly formed tumors show spindle cells in a loose fibrous network. There unquestionably exists a variety of fibroma originating from a nerve sheath, and because of nerve-contained filaments it is worthy of the name neurofibroma. Other mixed forms contain vessels, glandular structure, and muscle.

Etiology.—While little is known of the true cause for the development of these peculiar formations, Hebra's acute powers of observation were well displayed when he directed attention to the physical and mental condition of subjects of this affection. Patients are either dwarfish or poorly nourished individuals showing a low grade of mentality. The disease is at times seen in several successive generations and its heredity seems quite well established. The thyroid gland is often so poorly developed as to be with difficulty palpated.

Prognosis.—Fibroma is a life-long affection, unless relieved by surgical procedure, or, as extremely seldom happens, it disappears spontaneously. Life is in no wise jeopardized by the progress of the tumors even to an enormous size, unless in so growing they encroach upon some vital organ or important function. Naturally, an enormous tumor acts as a drain upon the constitution, requiring blood supply for its nutrition, and it may so deplete an already frail constitution as to occasion marasmus or pave the way for an intercurrent deadly affection. A further source of danger lies in the possibility of a degenerative process or of septicæmia.

Treatment.—If the number of growths is limited, they may be removed by excision or by the galvanocautery. Very small, pendulous tumors are best snipped with scissors. Large single growths may be treated upon surgical principles, while widely disseminated multiple lesions, especially when heredity is a factor and there are marked constitutional symptoms, are best left to themselves. *Charles Warrenne Allen.*

MONO-ACETYL-RESORCIN, $C_6H_3.CH_3CO.(OH)_2$, is used like resorcin in skin diseases. *W. A. Bastedo.*

MONOBROMACETANILID.—(Antisepsin, Asepsin.) Very soon after the therapeutic value of acetanilid had been recognized, this bromine compound was introduced as an anodyne, analgesic, and antiseptic. It is formed from acetanilid, $C_6H_5NHC_2H_3O$, by the substitution of one atom of bromine for one of hydrogen, its formula being $C_6H_4BrNHC_2H_3O$. It occurs in white acicular crystals, and is tasteless; it is insoluble in water, slightly soluble in glycerin, and very soluble in alcohol and ether.

In doses of five-sixths of a grain, four times a day, it lowered the temperature in phthisis, typhus, and typhoid fever, slowing the pulse at the same time, but not affecting the respiration. In pneumonia it was found liable to produce cyanosis. It was also used in neuralgia with success, in doses of from five to eight grains.

The employment of this compound has failed to become general, as it was found that prostration and cyanosis frequently accompanied its use. Cases have been reported in which two doses of five grains, taken at long intervals, produced very alarming symptoms (*British Medical Journal*, February, 1890, 357). *Beaumont Small.*

MONO LAKE.—Mono County, California.

This remarkable body of water is located near the centre of Mono County, about ten miles south of the town of Bodie. The length of the lake from east to west is about fourteen miles, and its greatest breadth nine miles. Its altitude is 6,370 feet above the sea level. In his article on the "Mineral and Thermal Springs of California," read before the Ninth International Medical Congress, Prof. W. F. McNutt likens this lake to the Dead Sea of the Holy Land. The analysis shows, however, that the waters of this lake (see below) are not so salty as those of the ancient Palestine sea. The lake receives much of its water and its salts from the rivers and creeks which flow through volcanic soil and empty into it. Numerous springs are found all over the lake. The most curious of these are some of the fresh-water springs, holding in solution small quantities of calcium carbonate, which precipitate and deposit around the openings of the springs, forming irregular tubes clustered together in columns. These vase-shaped structures are from ten to forty feet

long and rise from the bottom of the lake upward and above the surface. In the centre of these columnar pillars are small holes through which flows this sweet water. In Mono Lake we find several islands, some of them two or three miles in length. Their composition is of volcanic material, and all over the surface are hot springs and jets of hot steam, making the surrounding water quite warm. On several of these little islands are small craters, fifty or more feet in diameter. They are now filled with water. All around Mono Lake are unmistakable evidences of great volcanic activity during the tertiary and post-tertiary periods, and there are the best of reasons for believing that the lake itself is a large extinct crater. The water, being likened to the Dead Sea, was supposed to be destitute of life. There are found, however, numerous worm-like minute organisms, plainly visible to the naked eye in the water near the surface. The larvæ of these animals are thrown upon the shores of the lake by the waves, and there accumulate in large quantities. The fact that snow-capped mountains surround Mono Lake lends a grand and impressive character to its scenery. To the taste the water is more like a bitter brine than a mineral water. The action of the water, even when it is taken in small quantities, is exceedingly diuretic. Several analyses of this water have been made. The following one by Dr. Winslow Anderson is, perhaps, the most complete and comprehensive:

ONE UNITED STATES GALLON CONTAINS:

Solids.	Grains.
Sodium chloride	795.24
Sodium carbonate	26.40
Sodium sulphate	17.10
Sodium phosphate	5.93
Potassium chloride	281.17
Potassium carbonate	10.60
Potassium phosphate	3.05
Magnesium chloride	365.60
Magnesium carbonate	9.45
Magnesium sulphate	127.50
Calcium chloride	1,075.55
Calcium carbonate	52.76
Calcium sulphide	Trace.
Calcium sulphate	57.07
Ferrous carbonate	7.14
Alumina	26.63
Borates	19.75
Silicates	9.62
Organic matter	24.60
Total solids	2,915.16
Gases.	**Cu. in.**
Free carbonic-acid gas	17.16
Free sulphureted hydrogen	.62
Temperature of water, 63° to 80° F.	

The composition will probably vary somewhat in different localities, being influenced by the proximity of the various springs. *James K. Crook.*

MONO-PHENETIDIN CITRIC ACID, apolysin, $C_6H_4.OC_2H_5.NH.CO.C_3H_4OH$, is a citro-phenetidin which differs from phenacetin in the substitution of the citric for the acetic acid radical, and from citrophen, which is a triphenetidin citrate, in that only one-third of the acidity of the citric acid is satisfied. It is a light yellowish or whitish crystalline powder of acid reaction, and is soluble in fifty-five parts of cold water, its own weight of boiling water, and in alcohol, glycerin, and strong nitric and sulphuric acids. Nencki, Jaworski, Seifert, Louis Fischer, and others testify to the valuable antipyretic and analgesic effects of the drug, and Cerna reports its comparative lack of toxicity among the phenetidin compounds. Cerna's investigations show that medium doses have no effect on the circulation, while large quantities reduce blood pressure by cardiac depression. Respiration is stimulated. Forty-five grains in small doses administered intravenously to a ten-pound dog produced failure of circulation and respiration, cyanosis, and death. For influenza, migraine, neuralgia, neuritis, etc., it may be used as an analgesic and sedative, in acute rheumatism as a sedative and antipyretic, and in tuberculosis and other fevers as an antipyretic. Dose 0.3 to 2 gm. (gr. v.–xxx.). *W. A. Bastedo.*

MONSTERS. See *Teratology*.

MONTEBELLO SPRINGS.—(Formerly Newbury Springs.) Orange County, Vermont.

POST-OFFICE.—Newbury. Hotels.

ACCESS.—Viâ Boston and Maine Railroad, Passumpsic division. These springs are located in the midst of pleasing and picturesque scenery in the northern Connecticut valley. From no other point does the White Mountain range present more majestic and impressive views than from "Montebello," or Beautiful Mountain, and from no other point on the river are more varied, extensive, and charming valley and meadow landscapes visible to the eye. Two springs are mentioned in the geological reports, but it appears that only one is developed. The water was analyzed by Professor Hall about 1866 with the following result:

ONE UNITED STATES GALLON CONTAINS:

Solids.	Grains.
Sodium carbonate	0.40
Magnesium carbonate	.24
Calcium carbonate	17.60
Potassium nitrate	.40
Sodium sulphate	.24
Iron phosphate	.40
Sodium chloride	.32
Sodium sulphide	.32
Iron oxide	Trace.
Insoluble silica	8.80
Organic matter and ammonia	.24
Loss	8.64
Total	37.60

This analysis presents a mild alkaline-calcic water. It ought to possess diuretic and light antacid properties, besides being somewhat tonic. It has long been resorted to, especially for the treatment of rheumatism and cutaneous diseases. Excellent bathing facilities are provided for guests. *James K. Crook.*

MONTE CARLO AND MONACO.—These two promontories separated by the little plain of La Condamine, occupy one of the most beautiful positions on the Riviera. Monte Carlo, the more important of the two, is a small town of about 3,800 inhabitants, but is said to have upward of 1,000,000 visitors yearly; the larger number being attracted by the "Casino," the notorious gambling palace. From Nice on the one side Monte Carlo is only nine miles distant, and from Mentone on the other, six miles. The general climatic characteristics are essentially the same as those of Nice and Mentone, and the reader is referred to the articles upon these places in the HANDBOOK for meteorological data. The mean winter temperature is 48° F., and the rainfall and proportion of sunny days to cloudy ones is about the same as at Nice and Mentone. Every writer emphasizes the beauty and attractiveness of this region, and the present writer from personal acquaintance heartily confirms this opinion.

Monte Carlo is considered one of the warmest winter stations on the Mediterranean coast, and is well protected from the cold winds, this being particularly true of the little plain of the Condamine lying on the harbor and bay of Monaco. The northwest portion of this quarter is protected by the rock of Monaco to the west and southwest, and by the high mountains, which approach within a short distance of the sea, to the north and northwest. Also on the opposite side of Monte Carlo good protection is afforded from the cold winds. The sea bathing is excellent, and the accommodations are abundant and good, but perhaps rather more expensive than some of the other Riviera resorts. Naturally, Monte Carlo is one of the best winter stations on the coast, but the moral atmosphere of the place, on account of its unenviable reputation as a gambling resort, is hardly conducive to the well-being of an invalid.

Although the situation of Monte Carlo is one of great

natural beauty, art has done much to add to the attractiveness of the place. In corroboration of the truth of this statement I have only to point to the beautiful gardens in front of the "Casino," in which gardens are to be seen many exotic trees and plants. The excursions round about are many and varied; the most beautiful of all being the one to La Turbie and the walks from that point. La Turbie is 1,594 feet above sea level, and is reached in twenty minutes by a mountain railway from Monte Carlo. The views both in the ascent and at the summit are superb, and from La Turbie one can see the famous Corniche road in either direction.

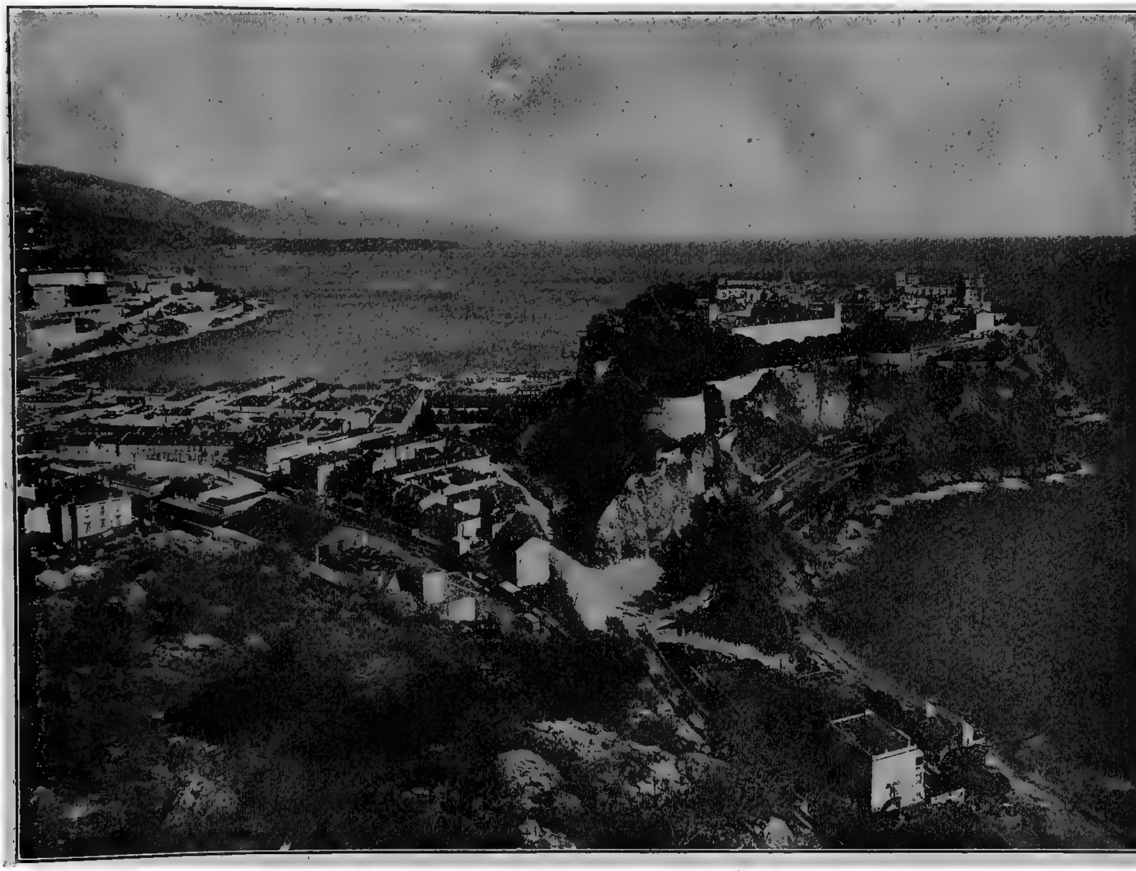

FIG. 3362.—General View of the Principality of Monaco.

The maladies for which one seeks the resort of Monte Carlo are such as are benefited at the other Riviera stations, such in brief as require a mild sunny winter climate. The malady of gambling, however, is likely to meet with a fatal issue at this resort where

"Every prospect pleases,
And only man is vile."

Edward O. Otis.

MONTEREY, CALIFORNIA.—This old Spanish settlement is one hundred and twenty-five miles south of San Francisco by rail, and is situated on a peninsula which forms one of the sides of the Bay of Monterey, Santa Cruz forming the other. The climate is moist, equable, and mild, and outdoor life can be enjoyed throughout the year. The annual mean temperature (Solly's "Medical Climatology") is 56° F.; maximum, 88° F.; minimum, 26° F. The mean temperature for January is 50° F. and for July, 65° F. The mean annual rainfall is 14.4 inches. Fogs are more or less prevalent.

The scenic attractions at and about Monterey are very great; the roads are good and the drives most attractive, while boating, bathing, and fishing can be enjoyed in the bay. The Hotel Del Monte is a vast structure attractively situated in a great park of several thousand acres with lawns, flower gardens, and groves of various trees, and it affords excellent accommodations.

For those desiring *rest* in a sedative, mild, equable climate, amidst beautiful scenery of sea and land, Monterey offers an ideal retreat. It is said to be "an excellent place" (Hinsdale "A System of Physiologic Therapeutics," vol. iv., Book II., "Climatology") "for the relief of *insomnia* and for building up the *neurasthenic.*" It is obviously not so well suited for the consumptive on account of its dampness. *Edward O. Otis.*

MONTESANO SPRINGS.—Jefferson County, Missouri.

POST-OFFICE.—Sulphur Springs Landing. Hotel.

ACCESS.—From St. Louis viâ St. Louis and Iron Mountain Railroad, twenty miles south; also by steamers on the Mississippi River. The springs are situated in a broken but picturesque region, about 600 feet above the sea level. They are twelve in number. The flow of water is estimated at from 1,500 to 3,000 gallons per hour.

The waters are laxative, and also possess alterative properties. Their continued use in small doses produces favorable results in cases of chronic constipation and dyspepsia, and in disorders of the blood, liver, and kidneys. The accommodations for visitors are limited as yet, consisting of a small hotel and a few private houses where boarders are taken. The water is shipped from the springs in pint, quart, and half-gallon bottles. A peculiar creamy substance, the natural product of one of the springs, is also used commercially. It has not been

analyzed, but is said to be highly efficacious as a local application to old sores, ulcers, or raw surfaces of any kind.

The following analyses of the two principal springs were made by Messrs. Potter and Riggs, of the Washington University:

ONE UNITED STATES GALLON CONTAINS:

Solids.	Montesano Spring. Grains.	Casco Spring. Grains.
Calcium carbonate	71.45	69.97
Magnesium carbonate	14.05	15.50
Calcium sulphate	32.37	33.93
Iron and alumina	.87	.75
Sodium hyposulphite	.74	.65
Calcium phosphate	Trace.	Trace.
Sodium sulphide	.34	.43
Sodium chloride	365.11	368.21
Potassium chloride	16.37	16.99
Magnesium chloride	35.91	34.41
Magnesium bromide	Trace.	.11
Magnesium iodide	.85	
Silica	.51	.67
Total	538.57	541.62
Gases.	**Cubic inches.**	**Cubic inches.**
Carbonic acid	46.43	43.20
Sulphureted hydrogen	1.40	1.60

Other springs at Montesano are the "Council," "Alton," "Pearl," and "Thorne" Springs.

James K. Crook.

MONTGOMERY WHITE SULPHUR SPRINGS.—Montgomery County, Virginia.

POST-OFFICE.—Montgomery Springs. Hotel and cottages.

ACCESS.—Viâ Norfolk and Western Railroad to Big Tunnel Station, thence by a narrow-gauge branch railroad direct to the reception house on the springs lawn.

This attractive summer resort is located in the Alleghany Mountains, at a level of over 2,000 feet above the tide-water. It is surrounded by the pleasing features which render the old Virginia mountain resort famous. The high elevation, cool and invigorating atmosphere, delightful scenery, romantic walks, and picturesque drives, together with an excellent and well-kept hotel, serve to make the Montgomery Springs a very desirable point both for the tourist in search of recreation or diversion and for the invalid who seeks to restore his health. Among the objects of interest in the neighborhood may be mentioned the Dudley Cascade, having a fall of ninety feet over a rugged cliff of solid rock. The falls are two and one-half miles from the springs and are reached by a lovely drive over a well-graded road along the banks of the Roanoke River. Twenty-one miles distant is the celebrated mountain lake, the next highest point in Virginia, having an elevation of more than 4,800 feet.

The waters of the springs issue from three bold sulphur fountains, and from a chalybeate and a freestone spring. They are gathered in handsome marble reservoirs surrounded by tasteful pavilions. Suitable arrangements for warm and cold sulphur baths are provided. A complete analysis of the water is wanting, but we have secured the following facts regarding their medicinal uses. The White Sulphur water contains sulphates and chlorides, the principal ingredients being the sulphates of sodium, calcium, magnesium, and manganese, with a considerable proportion of sulphureted hydrogen gas. It is used with much benefit in disorders of the liver and skin. It acts also upon the system as a mild laxative, a diuretic, and a diaphoretic. The water tends to relieve portal congestion and diminishes abdominal plethora. It is recommended by physicians in malarial affections of the spleen and liver, in rheumatism and gout, in incipient tuberculosis, and in chronic metallic poisoning. The chalybeate water contains a large percentage of carbonate of iron, and also the carbonates of magnesia, lime, lithia, and manganese, and a number of sulphates. It is used with much advantage in chlorosis, amenorrhœa, albuminuria, dyspepsia, and chronic diarrhœa, and other disorders. The average temperature of the water is about 50° F.

James K. Crook.

MONTREAL, CANADA.—Montreal (Latitude 45° 30′ N.; Longitude, 4 h. 54 m. W.), the commercial metropolis of Canada, with a population, including its suburbs, of 350,000, is picturesquely situated at the head of the ocean navigation of the St. Lawrence River, here nearly two miles wide. The city is built on a series of natural terraces which rise from the river's edge till they culminate abruptly in Mount Royal, a volcanic hill 750 feet high about two miles northwest of that portion of the river termed the harbor.

The buildings are, for the most part, well constructed of limestone and brick, and while cool in summer are rendered by their double windows and doors warm and comfortable in winter.

The soil on which the city is built is composed of a series of marine clays and sand with some gravel terraces. While some of the streets in the lower portion of the city are narrow and ill-paved, all the more important thoroughfares are broad, well-paved, drained, and lighted and are kept cleanly; those in the upper part of the city are lined on each side with shade trees which in summer add much both to their appearance and to their pleasantness. The city is well supplied with water drawn from the St. Lawrence River. This water, except during the time of the spring floods and after heavy autumn rains, has a very slight tinge of color and contains only a small amount of solid matter, not more than from eighty to one hundred parts per million, with chlorides from one to two and one-half parts per million; its total bacteriological content is from 120 to 240 per cubic centimetre. Montreal has an excellent street railway; its parks are numerous; the largest, comprising over three hundred acres, occupies the greater portion of the sides and top of the mountain and is well laid out with carriage drives and bridle and foot-paths.

Montreal is one of the most important educational centres in Canada; it possesses two well-equipped universities: one English, which is Protestant but undenomina-

TEN YEARS (1885-94) MEANS OF BI-HOURLY TEMPERATURES AT MONTREAL. (DEGREES FAHRENHEIT.)

Month.	1 A.M.	3 A.M.	5 A.M.	7 A.M.	9 A.M.	11 A.M.	1 P.M.	3 P.M.	5 P.M.	7 P.M.	9 P.M.	11 P.M.	Means.
January	11.34	10.59	9.76	9.53	10.41	12.88	14.37	14.95	13.92	13.5	12.69	12.13	12.17
February	12.21	11.46	10.49	9.95	11.82	14.6	16.24	17.01	15.85	14.86	14.16	13.45	13.51
March	22.39	21.41	20.09	20.36	23.08	25.98	27.76	28.42	27.55	25.83	24.68	23.81	24.28
April	36.78	35.46	34.14	36.38	39.86	43.32	45.47	46.27	45.65	42.31	40.25	38.73	40.39
May	50.66	49.12	47.73	51.08	55.29	58.76	61.41	62.33	61.22	57.55	54.77	52.81	55.23
June	60.69	59.4	58.64	62.26	65.82	69.13	71.21	71.8	70.31	66.86	63.89	62.23	65.19
July	64.25	62.82	62.11	65.69	69.65	73.07	75.04	75.75	74.02	70.25	67.42	65.83	68.83
August	61.44	60.32	59.44	62.02	66.22	69.75	71.78	72.09	70.39	66.3	63.9	62.53	65.52
September	54.48	53.46	52.77	54.04	58.25	61.91	63.78	64.29	62.53	58.68	56.93	55.52	58.05
October	43.0	42.16	41.65	41.69	44.98	48.2	49.72	49.94	48.1	45.77	44.43	43.5	45.26
November	31.95	31.49	31.03	30.77	32.44	34.64	35.64	35.56	34.28	33.37	32.54	31.88	32.97
December	18.64	18.31	17.37	16.83	17.73	19.71	20.73	21.02	19.96	19.61	19.12	18.77	18.98

Mean for Ten Years, 1890-99.

Month.	Thermometer. (Degrees Fahrenheit.) Maximum.	Minimum.	Mean daily range.	Mean relative humidity.	Per cent. possible bright sunshine.	Inches of rain.	Number of days on which rain fell.	Inches of snow.	Number of days on which snow fell.	Inches of rain and melted snow.	Number of days on which rain and snow fell.	Number of days on which rain or snow fell.
January	42.37	− 17.58	15.24	84.07	36.63	0.9	4.3	28.41	18.7	3.72	2.5	20.5
February	41.66	− 13.02	15.03	82.97	43.27	.69	3.2	23.52	15.1	2.98	1.9	16.9
March	46.6	− 1.29	13.96	77.81	47.99	1.53	7.6	18.94	11.7	3.68	3.2	16.1
April	70.07	17.05	16.96	67.16	51.78	1.7	11.4	3.56	3.7	2.05	1.4	14.2
May	80.49	33.97	18.25	68.14	49.59	2.98	16.6	....	....	2.98	....	16.6
June	85.95	46.19	17.39	71.71	52.94	4.1	15.6	....	....	4.1	....	15.6
July	88.54	50.56	17.06	72.59	59.96	3.94	17.6	....	....	3.94	....	17.6
August	86.04	48.26	16.13	74.47	56.41	4.25	16.9	....	....	4.25	....	16.9
September	82.21	37.43	15.8	76.94	53.15	3.14	14.8	....	....	3.14	....	14.8
October	70.7	27.71	13.52	77.27	40.68	2.45	14.9	2.5	1.6	2.48	1.0	15.5
November	56.46	9.01	12.63	80.13	28.87	2.13	11.1	10.68	9.7	3.24	2.8	17.9
December	45.91	− 8.64	14.19	84.22	32.88	1.46	5.5	22.68	16.6	3.29	2.2	19.9

tional, the other French and under the control of the Roman Catholic Church. There are also numerous public and private schools, in both languages, of a high order of excellence. There are a public library, an art gallery, and several very fine private collections of paintings.

The flora of the district is a very rich one and comprises not less than one thousand species of flowering plants. Several kinds of elm, maple, ash, and birch flourish in the district; also the oak, beech, butternut, poplar, willow, and lime trees.

The St. Lawrence River runs in a northeasterly direction through a broad alluvial plain, bounded on the north by the Laurentides, a range of undulating hills from one to two thousand feet high, composed chiefly of metamorphic rocks and holding in their valleys numberless small lakes and watercourses. Bounding this plain on the south are the northern spurs of the Adirondacks, the Green Mountains, and the Appalachians. Toward the centre of it rise several isolated hills of volcanic origin from five hundred to eight hundred feet high, composed chiefly of trap rock, their sides and summits for the most part well wooded. Four miles above Montreal the river tumbles in a series of small cataracts over a rocky ledge forming the "Lachine Rapids," and still farther up, at a distance of about nine miles, it widens into Lake St. Louis, six miles broad.

In Montreal and its neighborhood winter as a rule is most enjoyable and healthful. Snow falls about the latter half of November, and generally remains until the later weeks of March; only occasionally during all these months does a thaw occur for a few days. The air is dry and cold, but the cold is rarely extreme, and, owing to the dryness of the air, is quite endurable. The sunshine is bright, and there is an absence of high winds. During the bright and starlit nights outdoor sports of all kinds may be enjoyed; of these the most notable are sleighing, snow-shoeing, skating, skiing, and tobogganing. In spring the melting snow in the streets, with the accumulated dirt of the winter, is apt to render the last two weeks in March and the first two weeks in April decidedly insalubrious. Bright, warm weather generally sets in with the first week of May. The summer is warm and dry, but showers are sufficiently frequent to maintain the general verdure. The heat of the day is followed by an evening and night always sufficiently cool to permit of restful sleep. The autumn is bright, cool, and invigorating. The accompanying tables present the average meteorological data for the past ten years.

Montreal has connections by rail with all the important points on the continent, and is the terminal port of the Canadian steamship service to Europe, and of the several steamship lines which connect it with the summer resorts on the upper and lower St. Lawrence, the Gulf, the Lower Provinces, and Newfoundland.

Alexander D. Blackader.

MONTREUX.—The village of Montreux, in the Canton de Vaud, Switzerland, lies at the northeast corner of the Lake of Geneva (Latitude 46° 25′ 59″ N., Longitude 6° 55′ E.), directly opposite the opening of the Rhone Valley. Beside Montreux proper some twenty other villages and hamlets, lying close together at this point, are included in the district, or parish, bearing the same name; and it is all these places taken collectively which constitute the health station of Montreux. Of the other villages comprised within the district, Les Bassets, Clarens, Vernex, Territet, and Chillon are perhaps those most widely known. Glion, 1,000 feet above Montreux, and Les Avants, about 2,000 feet above Montreux, are also well-known health stations. The elevation of Montreux itself above sea level is 1,220 feet. The chief climatic characteristics of this district are its immunity from cold winds and the prevailing stillness of its atmosphere, both of which are due to the very exceptional degree of shelter afforded by the mountains which stand back of the district to the north and east. Montreux itself is the most sheltered of all the group of contiguous villages. "The indentation of the lake, which is here called the Bay of Montreux, is protected by the mountains around from the north and east winds, and in some degree from the northwest wind, so that it is said to be, with the exception of Bex, the most sheltered place in Switzerland. It is also the hottest of all the Swiss stations north of the Alps except Sion, but that applies only to the summer and spring, as Montreux is warmer than Sion in autumn and winter. The 'bise'—the cold northeast wind—is not nearly so much felt at Montreux as at Geneva and Morges; and it has been noticed, during the prevalence of a 'bise,' that it has been intensely cold at Geneva (temperature 14.3° F.) and at Morges (temperature 18° F.), while at Montreux (temperature 23.6° F.) the air has been almost calm and not disagreeably cold. There are also less variations of temperature at Montreux—a smaller range between the maxima and minima" (Dr. J. Burney Yeo, "Climate and Health Resorts"). To the "föhn" wind blowing up from the south, down the Rhone Valley, Montreux is much exposed. Dr. Yeo tells us that at Montreux "the air is very calm and still, the number of calm days reaching eighty-five to ninety per cent., whereas at Morges it only reaches thirty-three per cent., and it has been noticed that the lake is often calm from Vevey to Villeneuve, when it is agitated in the rest of its extent. But when the hot wind blows from the south, the *föhn*, here called the *vaudaire*, . . makes the bay of Montreux very rough." The winter temperature of Montreux is moderately cold. Dr. Kisch, in Eulenburg's "Reäl-Encyclopädie," gives the following figures for the mean temperature of each of the seven months from October to April: October, 50.9° F.; November, 41.2° F.; December, 36.5° F.; January, 33.4° F.; February, 39° F.; March, 41° F.; April, 50.7° F. The mean temperature at the hours of 7 A.M., 1 P.M., and 7 P.M., in each of the four seasons, and in each of the seven colder months of the year; the mean temperature of the winter, of the spring, and of the year; and the mean and absolute maximum and minimum temperatures, all of them derived from seven years of observation, are given by Dr. Yeo, and are quoted below:

	7 A.M.	1 P.M.	7 P.M.
	Degrees.	Degrees.	Degrees.
October	47.0	56.6	49.0
November	38.7	47.5	41.0
December	34.3	41.5	35.9
January	31.8	39.7	33.9
February	35.0	44.0	38.1
March	37.0	45.2	39.7
April	46.0	57.6	50.4
Spring: March to May	46.6	56.4	49.4
Summer: June to August	61.7	72.7	63.7
Autumn: September to November	47.3	57.4	49.8
Winter: December to February	33.8	41.7	35.9

	Degrees.
Mean annual temperature	51.0
Mean winter temperature	36.5
Mean spring temperature	50.8
Mean maximum temperature (July)	77.0
Mean minimum temperature (January)	35.2
Absolute maximum temperature (July 8th, 1870)	89.0
Absolute minimum temperature (February 12th, 1865)	11.4

Dr. Kisch states that the nycthemeral range of temperature at Montreux varies from 12° C. to 16° C. (53.6° F. to 60.8° F.); but this statement is very surprising in view of the figures just quoted from Dr. Yeo. The mean annual rainfall is fifty inches; the number of rainy days in winter and spring is twenty-one, the total number of such days throughout the year being sixty (Dr. Yeo). Dr. Kisch puts the annual number of rainy days at seventy, and tells us that the mean relative humidity is 74.7 per cent.

Snow falls, of course, at Montreux, but how frequently and to what depth I do not know. In Flechsig's Bäder-Lexikon we are told that the snow melts rapidly, a thing which might readily have been inferred from the sheltered position of Montreux, freely exposed only to southerly and southwesterly winds. We are also told by the same authority that, despite the very considerable degree of winter cold and the occurrence of snow, there are, almost every winter, even in December and January, certain days during the warmer part of which an invalid can safely sit out in the open air for several hours.

As a rule, fogs occur but rarely during the winter season; yet they were frequent in the winter of 1875–76.[1] What remains to be said respecting the climate cannot be better told than by direct quotation from Dr. Yeo's admirable work on "Climate and Health Resorts."

"In an average winter a good deal of cold weather must be expected at Montreux, as its mean winter and spring temperature is some 5° F. lower than that of Ventnor, and 4° F. lower than that of Torquay; but in favorable seasons, on the other hand, a good many bright, clear, sunny days may be expected, and comparatively few rainy ones. In November there are often a good many cold, damp, and disagreeable days.

"In spring the weather is often very variable. There are, perhaps, some very fine days, and then a sudden and unexpected return of cold, with rain or snow; so that invalids need to take great precautions at this season. Patients often ascend to Glion at this period of the year. Few people spend the summer at Montreux on account of the heat, but the autumn is a fine season up to the middle of October, when storms of rain frequently set in and there is occasionally a passing snowfall. It is in the autumn that the grape cure is in active progress at Montreux.

"It is an advantage at Montreux to have two mountain stations of different elevations, such as Glion and Les Avants, so readily accessible; for it does happen during some seasons that there is much more sunshine to be found at the higher resorts than at the lower one, and this fact is easily ascertainable.

"The winter and spring climate of Montreux, it will be seen, is by no means a perfect one; it has, however, been pointed out, as a kind of compensation, that the hotels and *pensions*, which abound here, are very comfortable, and that if the weather out of doors is bad, the invalid can find good shelter and protection indoors."

With reference to this last statement of Dr. Yeo's, it is perhaps well to remark that Dr. Kisch[2] pronounces Montreux to be very inferior to Meran, in respect to out-of-door accommodations for invalids, such as parks (Anlagen), roads, and resting-places (Ruheplätze); he says that there is a lack of variety in the food provided, and that it is not especially nourishing (nicht besonders kräftig), and that those who stay long at Montreux, even in the autumn, are apt to suffer from *ennui*. Nevertheless, despite its climatic inferiority in many respects to many more southerly health resorts, the general excellence of its hotels and *pensions*, the moderate cost of living, and the facilities for good schooling which there exist, still combine to render Montreux an attractive place of winter residence to many families; and to these attractions must be added the surpassing beauty of the scenery. The view of the Savoy Alps, which rise like a wall on the opposite side of the lake, and of the grand, snow-crowned peaks which hem in the Rhone Valley, must be seen to be adequately appreciated.

CLIMATOTHERAPY.—The climate of Montreux is said to be unsuited to cases of advanced pulmonary phthisis, accompanied by marked febrile symptoms [cases of phthisis with fever had best remain at home.—E. O. O.] or by free secretion, and also to nervous patients having a tendency to depression of spirits.[3] Dr. Yeo tells us that prolonged residence at Montreux is said to be serviceable in "cases of simple chronic laryngitis, of chronic laryngo-pharyngitis, of granular pharynx"; and that "all these chronic throat affections have a good chance of cure at Montreux, especially if they are, at the same time, submitted to local treatment by inhalation," etc. He includes in his list of cases, said to be benefited by prolonged sojourn at Montreux, "cases of recurrent bronchial catarrh or tendency to catarrh, as well as cases of chronic bronchial catarrh when not too inveterate or severe; persons with hereditary predisposition to consumption, and cases of chronic phthisis and early phthisis when the general health and strength are otherwise good and there is an absence of fever; cases of chronic pleurisy with suspicion of the commencement of phthisis, as well as cases of chronic empyema healing slowly; cases of cardiac valvular disease of rheumatic origin, to ward off bronchial catarrh and fresh rheumatic attacks, also cardiac neurosis, especially if induced by excess of tobacco-smoking."

For information concerning the "grape cure," which is practised during the autumn at Montreux, and at certain other resorts in Switzerland, and elsewhere in Europe, the reader is referred to the article on *Meran*.

Huntington Richards.

[1] J. Burney Yeo: Climate and Health Resorts.
[2] Article on Montreux, in Eulenburg's Reäl-Encyclopädie, vol. ix.
[3] Robert Flechsig: Bäder-Lexikon, art. "Montreux."

LES AVANTS AND GLION.—[These two resorts are in such close proximity to Montreux that mention may be made of them in this connection. Les Avants is 3,230 feet above sea level, and is reached from Montreux by a mountain railway to Glion and from thence by carriage road; or all the way from Montreux by road, in an hour and a half. It is both a summer and a winter climatic station. The plateau upon which this resort stands is sheltered from the north and east by mountains, which are well wooded, and is open to the south. The climate is a mild, slightly tonic, mountain one. "The air is pure and free from dust; the heat is modified in summer by the woods and the lakes, and in winter the sun is very powerful, and the sky almost free from cloud." . . . "Great and frequent changes of temperature are, however, of not infrequent occurrence, and prove very trying to consumptive patients" (Loetscher, "Handbook to the Health Resorts of Switzerland").

It snows about twenty-eight days in winter, the sky is overcast forty-seven days and quite clear during sixty-seven. The air is very dry. The meteorological data given under Montreux are applicable to Les Avants, allowance being made for the difference in elevation. The

snow generally disappears by the middle of March, and by April the vegetation is well advanced. By May the flowers are in the meadows. For such cases as require a milder climate and lower elevation than the higher Alpine resorts, such as Davos, St. Moritz, Arosa, Leysin, etc., Les Avants can be recommended. The "Grand Hôtel des Avants" affords excellent accommodations, at moderate prices. The cases to which this climate is applicable are incipient pulmonary tuberculosis without active symptoms, in individuals of good general health; bronchitis with scanty expectoration, tardy convalescence from pleurisy and pneumonia, asthma of a neurotic origin; anæmia, chlorosis, and scrofula.

Glion, 2,300 feet high, is reached by a cable railway from Montreux in six minutes. It is situated on a mountain spur, affording from its Rigi-like terrace "a magnificent view, surpassing in extent all others on the bay." It is well protected from the north and east winds, and enjoys a comparatively mild winter; hence it is adapted for a winter-cure station of moderate elevation, although it is most frequented in spring, summer, and autumn.

Like Montreux it has a milk and grape cure, as well as a Terrain cure. It is known for the purity and dryness of its air and its equable temperature. In the height of summer it is a very popular resort for visitors from Montreux. The climate of Glion is suitable for much the same class of cases as that of Les Avants. It is especially recommended for nervous patients, convalescents, the early cases of pulmonary tuberculosis, and weakly children. There are a number of good hotels and pensions, and during the summer there is an English church service.

Still higher than these two resorts is the Grand Hôtel de Caux (3,610 feet), open all the year round, less sheltered than Les Avants. (The mean annual temperature is 43° F., and relative humidity 55. Fog and mist are rare; and as in the other altitude resorts one can sit out in the sun in the depth of winter.) At the terminus of the mountain railway is the Rochers de Naye (6,470 feet), with a hotel open during the summer months.

Edward O. Otis.]

MONTVALE SPRINGS.—Blount County, Tennessee.

POST-OFFICE.—Montvale. Hotel and cottages.

ACCESS.—From Knoxville viâ Knoxville and Augusta Railroad, to Maryville, the present terminus of the line; thence by stage line to springs. The springs are twenty-five miles south of Knoxville. This resort is located at the foot of the Chilhowee Mountains, 1,300 feet above the sea level. The springs have been celebrated in East Tennessee for a period of fifty years or more, and long before the Civil War the location was a fashionable summer resort, where people of this and other States found health and pleasure during the heated term. From year to year extensive improvements have been made, and now we find among the picturesque mountains a watering-place supplying about everything which goes to make up a healthful and agreeable refuge from the summer heat of the semi-tropical Southern States. The big hotel building, with its seven gables, is located in a romantic spot, and around it cluster forty neat cottages, giving the place the appearance of a charming little village built among the forest trees. Walks, fountains, beautiful brooks, and flowers are found on every side, and with the evergreen mountains for a background form a picture of great loveliness. Fronting the hotel is a large park, with broad, smooth drives and walks, and grassy lawns, affording ample scope for outdoor diversions. Fountains, swings, hammocks, and rustic retreats are scattered here and there. The hotel is supplied by a system of water-works from the "Sweet William" Spring. The medicinal springs are the "Great Chalybeate" Spring, nearest the hotel, and the "Black Sulphur" Spring, on the road near Montvale. The following analysis of the Chalybeate Spring was made by Prof. S. B. Mitchell:

ONE UNITED STATES GALLON CONTAINS:

Solids.	Grains.
Calcium carbonate	13.26
Iron carbonate	2.40
Sodium sulphate	4.51
Calcium sulphate	74.21
Magnesium sulphate	12.00
Sodium chloride	1.96
Aluminum oxide	.50
Total	108.84

In addition to its ferruginous tonic effects this water also acts as a saline aperient. It has long been recommended as a safe and reliable remedy for many of the protean ills included under the name of dyspepsia. It is also valuable in uric-acid states, especially in those characterized by genito-urinary manifestations. The Black Sulphur Spring contains 109.30 grains of solids to the United States gallon, of which the sulphate of magnesia (grains 17.07) and the oxide of iron (grains 1.19) are the most important.

James K. Crook.

MOODYVILLE MINERAL SPRINGS. — Pottawatomie County, Kansas.

POST-OFFICE.—Moodyville. Hotel.

ACCESS.—Viâ Kansas Central Railroad to Blaine, thence four miles southeast to springs. These springs are three in number, and flow about twenty-five gallons per minute. According to an analysis by Prof. J. R. Eaton, of William-Jewel College, Missouri, the waters contain the following ingredients:

Calcium carbonate.	Sodium chloride.
Magnesium carbonate.	Iron (probably as carbonate), a trace.
Magnesium sulphate.	Silica, alumina, and organic matter, a small amount each.
Sodium sulphate.	
Free carbonic acid gas.	

The water is used in dyspepsia and disorders of the bowels, liver, and kidneys.

James K. Crook.

MOONSEED, CANADIAN. — MENISPERMUM. Texas sarsaparilla, Yellow parilla. "The rhizome and roots of *Menispermum Canadense* L. (fam. *Menispermaceæ*)" (U. S. P.). This is a prostrate and twining herbaceous vine, with excentrically peltate, angled or lobed, alternate leaves, and axillary panicles of pale-yellow, diœcious flowers.

Moonseed arises from a long, slender rhizome, which, with its adhering roots, is the official portion. It is dried in flexible, tough pieces, a metre or so in length, and about five millimetres in thickness, with a finely shrivelled brown bark and yellow section. Odor slight, taste bitter. It grows in most parts of North America, and was introduced into medical use, thirty or forty years ago, as a substitute for sarsaparilla in "scrofulous affections," etc. There is no evidence to show that it is anything but an inferior bitter tonic. Its composition —*berberine* and the white, crystalline, bitter alkaloid *menispine*, soluble in water—recalls its near botanical relatives, *columbo* and *pareira*. The dose is 4 to 8 gm. (ʒ i.–ij.), and a fluid extract is official.

The family *Menispermaceæ*, comprising about a hundred species, mostly woody climbers of tropical regions, is notable for the great number and variety of its bitter principles, on account of which a large number of its species are used as simple bitters. Among the most important of these are, in India, various species of *Tinospora*, especially *T. cordifolia* Miers, and the wood of *Coscinium fenestratum* Colebr., the latter known as Indian calumba and largely used in India as a calumba substitute. In South America, several species of *Abuta*, especially *A. rufescens* Aubl., and a number of species of *Cocculus* are similarly employed.

Henry H. Rusby.

MOORMAN MINERAL WELL.—Washtenaw County, Michigan.

POST-OFFICE.—Ypsilanti.

The waters of the Moorman Well are used to supply the Occidental Bath-house, which is situated near the

centre of the charming city of Ypsilanti, on the line of the Michigan Central and the Lake Shore and Michigan Southern Railroad. The bathing establishment contains forty large well-ventilated bath-rooms, besides parlors for ladies and gentlemen, smoking and reading rooms, and other adjuncts of a modern first-class institution of this kind. The water of this well has been in use since 1848, and has become widely known. The baths are highly recommended in uterine inflammations and congestions, in skin diseases, sciatica, and inflammatory rheumatism and gout. Internally the water is said to be valuable in constipation, dyspepsia, chronic alcoholism, and in hay fever. It is also used—by means of insufflation, in a douche, and in the form of a gargle—in nasal and pharyngeal catarrh. The following analysis was made by James H. Shepherd, of the Ypsilanti High School, in 1884.

One United States Gallon Contains:

Solids.	Grains.
Magnesium sulphate	103.76
Potassium sulphate	35.33
Ferrous salts	Traces.
Calcium sulphate	175.65
Magnesium bromide	10.97
Sodium sulphide	8.42
Phosphates	Traces.
Silicon dioxide	19.81
Calcium carbonate	57.26
Borates	Traces.
Sodium chloride	1,573.62
Lithium salts	Traces.
Calcium chloride	143.35
Barium salts	Traces.
Magnesium chloride	128.09
Strontium salts	Traces.
Organic matter	Traces.
Total	2,256.26

Sulphureted hydrogen gas, 26.84 cubic inches.

The bath-house is connected with the new Occidental Hotel, where ample arrangements are made for the comfort of guests. Ypsilanti also contains several well-known mineral wells. The most important of these are the Ypsilanti and Owens Wells. They are highly charged with mineral ingredients, and are also of the saline-calcic class. *James K. Crook.*

MORBIDITY. See *Vital Statistics.*

MORBUS MACULOSUS WERLHOFII.—(Purpura; Blutfleckenkrankheit.)—Definition.—A disease characterized by the spontaneous appearance of transitory hemorrhagic areas in the skin, mucous membranes, and internal organs, and rarely associated with hemorrhages from the mucous membranes.

Extravasation of blood into and beneath the skin occurs more or less constantly in a great variety of diseases and conditions, and as such is commonly known as "secondary or symptomatic" purpura. Besides this group we have a second in which the purpuric eruption, appearing without apparent cause and unaccompanied by marked constitutional symptoms, is in itself the chief symptom. To this is given the name "primary, essential, or idiopathic" purpura. Though strictly speaking a symptom only, in the latter case we may consider it a disease.

From the large group of diseases with subcutaneous extravasations of blood Werlhof, in the latter part of the last century, isolated one to which he gave the name purpura hæmorrhagica, a term probably corresponding more or less closely with primary purpura. Later writers separated purpura simplex as a distinct disease, and established purpura urticans as one of its subdivisions. Finally, peliosis rheumatica and Henoch's purpura were described. Such a division, however, except for the purposes of clinical work, is not warranted, since no fundamental differences separating these various forms exist. We find, instead, a variation in the severity of certain symptoms, with the various types constantly merging the one into the other.

Hoffmann, Litten, and others prefer to group all varieties of essential purpura under the term morbus maculosus Werlhofii, and to consider them from a general standpoint. In this broad sense the term is here used.

Etiology.—Accurate knowledge concerning the cause of purpura is entirely wanting, in most cases no explanation of the condition being possible. Its appearance is spontaneous and primary, never endemic or epidemic. Previous physical condition seems to be unimportant.

In a series of two hundred cases, McKenzie has shown the disease to be slightly more common in men than in women, and that seventy-seven per cent. of all cases occur during the first three decades of life. Other writers believe the disease to be somewhat more common at the age of puberty.

Such conditions as poor food, wet, exposure, fatigue, debility and starvation, though often enumerated, cannot be shown to be of more etiological importance in purpura than in many other diseases. Purpura is found with the same frequency among all classes. It is never hereditary. The hemorrhagic diathesis is not infrequently associated with certain nervous conditions (severe neuralgia, nervous shock, etc.), as pointed out by Weir Mitchell and others, and to these the relation appears certain.

Venous stasis, though in itself not sufficient to produce the disease, is undoubtedly an important factor. The character of the blood in some cases suggests a possible influence in producing the condition. We may find anæmia of a secondary or even a pernicious type, leucocytosis, and changes in its chemical composition, specific gravity, and reaction.

Silbermann and Koehler, working upon animals, were able to produce the subcutaneous hemorrhages by the use of certain ferments and toxic substances injected directly into the veins. In a few cases bleeding occurred from all the internal organs as well as into the skin. Silbermann regards purpura as a primary blood disease, "causing slowing of the current, stasis with the formation of thrombi, and subsequently degeneration of the vessel walls," leading to extravasation of blood into the tissues.

Much in the nature and course of the affection suggests an infectious origin, and many attempts have been made to isolate micro-organisms from the blood. In 1884 Petrone found in the blood of a purpuric patient small round bodies which he considered spores of a bacillus, to which he gave the name of bacillus purpuræ. Rabbits inoculated from the cultures developed the typical lesions, and careful examination of the tissues demonstrated the presence of the bacilli in the capillaries. Letzerich obtained similar results and considered purpura a characteristic infectious disease. He was himself finally stricken with the disease, and from his own blood grew cultures of a bacillus probably identical with Petrone's, which by inoculation into animals produced purpura. The bacilli and spores were constantly found in the petechiæ. Gimard, Tizzoni, Giovannini, and Kolb report the isolation of various bacteria from the blood and petechiæ of patients suffering from purpura. In spite of these striking results, we must await more conclusive evidence. We are justified only in saying that in many cases of purpura the infectious origin seems unquestionable.

Arjelio believes the cause to be one of auto-intoxication through the absorption, by the intestines, of decomposed albumin.

Symptoms.—A few symptoms are found more or less constantly in all grades of purpura.

Lesions in the Skin.—The cutaneous hemorrhages show an extraordinary variation. They may be round, oval, or irregular, single or confluent, and in rare cases indurated. Though commonly less than 1 cm. in diameter, they may be present as very large areas, or even the entire skin may be involved. In all cases these appear without local inflammation or hyperæmia, and on normal skin. The location of the spots is more often on the lower legs and feet, frequently on the arms and belly, more rarely on the face and chest. Their appearance is sudden and in crops, as it were. At first of a blood-red color, the areas almost immediately begin to fade, if superficial, first assuming a purplish tint, then a yellowish-green, later becoming a pale brown, the whole process

requiring from two to eight days. When the hemorrhage is deep, a bluish color is very often present; and if a considerable effusion of blood takes place, pigment is deposited which persists for weeks or months, and microscopically for years. Deep effusions of blood between the bones and periosteum give a faint blue color with deep induration, over which the skin is movable.

Hemorrhages.—In the severe forms of this disease actual bleeding from the mucous and serous surfaces occurs. Epistaxis is the form most frequently met with, but hemorrhage may also come from the throat, gums, stomach, intestines, kidneys, or bladder, or the blood may escape even into the serous cavities. Retinal hemorrhages are seldom seen.

Blood.—The blood in the majority of instances gives evidence of no striking changes, but in very severe forms one finds marked anæmia of a secondary character. In a few cases observed by Ajelio, Spietschka, Billings, and others, very profound diminution in the hæmoglobin, a considerable leucocytosis, increased blood plates, slight degeneration in the red corpuscles, and presence of a few blasts are recorded. In general, no uniform results have been obtained.

Fever of a moderate degree is often present, rarely hyperpyrexia. The pronounced febrile cases are usually of the severest form, and almost invariably end fatally.

Gastro-intestinal Symptoms.—Apart from anorexia these are wanting, or are only slight, except in the worst forms of purpura. Intense abdominal cramps, resembling the crises of locomotor ataxia or the colic of chronic lead poisoning, accompanied by vomiting and diarrhœa, are pronounced in occasional instances.

Albuminuria without evident nephritis of definite character is sometimes found, especially late in the course of the disease.

Throat Symptoms.—Osler calls attention to the occurrence of moderate symptoms of sore throat with local necrosis.

The symptoms of purpura are subject to extreme variations, both in their intensity and in their grouping, in many cases changing quickly from one type to another while under observation. As emphasized above, no accurate division of the disease into varieties is possible, but for purposes of description and clinical study we may describe three main forms, namely, purpura simplex, purpura rheumatica, and purpura hæmorrhagica. The prominent symptom of the first is the subcutaneous ecchymoses, of the second the arthritic phenomena, and of the third the bleeding from mucous surfaces. By many authors a fourth form is described, the so-called Henoch's purpura, in which the combination of marked abdominal symptoms, subcutaneous hemorrhages, and joint manifestations, are the distinctive symptoms.

Purpura Simplex.—Suddenly without prodromes, and in the majority of cases unaccompanied by constitutional symptoms, ecchymoses develop on the extremities. The eruption but seldom invades the trunk and face. In exceptional cases there may be constitutional disturbances, as slight fever, malaise, moderate digestive symptoms, rapidly increasing anæmia of a mild order, and even slight swellings with pain in the legs or arms. There is commonly slight diarrhœa. The patient usually recovers in a few days, but some cases have proved fatal after only a short course.

Under the name of *purpura urticans* are included those cases in which the ecchymoses take on the form of urticaria.

Purpura Hæmorrhagica.—The name morbus maculosus Werlhofii, which we have used to include all primary purpuric diseases, is often restricted to this form. To this group belong all severe and obstinate cases of purpura in which bleeding takes place from serous or mucous surfaces. It is often observed without fever or prodromes, but more frequently the attack is ushered in by definite constitutional disturbances (headache, malaise, pains all over the body, diarrhœa, and vomiting), which after a few days are followed by hemorrhages into the skin and bleeding from mucous membranes. In exceptional cases, this last-mentioned symptom precedes all others. The bleeding, although it comes more commonly from the nose or mouth, may also come from the lungs, stomach, intestines, kidneys, or bladder. Not infrequently the hemorrhage becomes profuse and uncontrollable, leading to alarming symptoms. The presence of moderate pain in the joints with local œdema and tenderness does not exclude cases from this group. Anæmia is frequently present, occasionally of an extreme character; in one of Billings' cases the hæmoglobin sank rapidly to fifteen per cent., and the red cells to 560,000 per c. mm.

A separate but needless division of purpura hæmorrhagica sometimes made is that of *purpura fulminans*, this term being applied to cases which are of a very violent nature. The acute onset, rapid course, and death in from one to five days, strongly suggest a septic fever.

Purpura Rheumatica (Peliosis Rheumatica, Schönlein's Disease).—The occurrence of an eruption either purpuric, urticarial, or erythematous, together with definite arthritic phenomena of pain and swelling, gastro-enteric symptoms, and a prolonged course, characterizes this affection. It is a disease of young adults. Unlike purpura hæmorrhagica, this form almost never shows a sudden onset; for several days or a week the patient complains of weakness, sore throat, fever, anorexia, vomiting, and other general symptoms. These are followed by shooting pains and stiffness in the muscles and joints, the typical course showing the earliest involvement in the lower extremities. The œdema, though exceedingly variable, is at times intense and may occur in any part of the body, even on the face. The rash, which frequently appears in the vicinity of the affected joints, ordinarily corresponds to the simple purpuric type, but may show urticarial wheals or even nodular infiltrated areas and vesicles. In the case of a young woman whom I saw at the Massachusetts General Hospital, the urticarial spots appeared with great regularity late every afternoon for a period of eight days. In the same case there was considerable necrosis of the soft palate and both tonsils. Opinions differ widely as to the relation of this disease to rheumatism, but at present we have no definite evidence of any rheumatic origin.

Henoch has described another form of purpura which occurs mainly in children, and is marked by ecchymoses beneath the surface of the skin, bleeding from the mucous membranes, joint manifestations, renal and gastro-enteric symptoms. Diarrhœa and vomiting with intense abdominal cramps are especially characteristic, as are also the occurrences of malæna and hæmatemesis.

Pathological Anatomy.—The petechiæ and ecchymoses constitute the only constant lesions. The conditions in the tissues in the immediate vicinity of the extravasations are of considerable interest. Many of the small blood-vessels show a very marked thickening with hyaline degeneration, and in many instances even necrosis of the wall, associated with extensive thrombus formation. About the vessels the connective tissue is densely infiltrated with blood corpuscles and blood pigment. Although this is not a constant occurrence, the muscle may show small hemorrhagic areas. Depending upon the severity and type of the disease, the mucous membranes and internal organs may likewise give evidence of hemorrhage. In a few instances, collections of blood have been found beneath the periosteum of the bones. No arthritic changes can be demonstrated beyond a moderate hemorrhage into the synovial membrane. Not uncommonly the spleen, Peyer's patches, and the lymph nodes are enlarged and contain much blood pigment.

Complications and Sequelæ.—The complications which are most serious and which are most frequently encountered, are those arising in consequence of the internal hemorrhages, either parenchymatous or into serous cavities. Nephritis sometimes develops, even years after the purpuric attack. Rarely pneumonia or œdema of the lungs complicates the disease.

Course and Prognosis.—As in its symptoms, the course of purpura in all forms is subject to great variations, depending very largely upon the severity. In gen-

eral it may be said that the majority of patients recover. When the disease is of a mild character, the course is short, varying from a few days to weeks, seldom more than three, and occasionally terminating with only one crop of spots, but more frequently only after there have been several crops. The duration of the more marked types of the disease, especially those with hemorrhages from mucous membranes, is much more protracted, being rarely less than several weeks, often as many months, and, through the occurrence of relapses, even years. In the worst forms, the patient often dies within a few days from the onset. With the arthritic type, repeated relapses are apt to occur, thus making the convalescence protracted even for months or years. A fatal issue is seldom seen.

Diagnosis.—Purpura so often accompanies other diseases that a diagnosis of the primary form may be difficult. One must always consider the possibility of the toxic form following various poisons, as mercury, phosphorus, and mineral acids, as well as the infectious purpura secondary to smallpox, scarlet fever, diphtheria, typhoid, measles, septicæmia, and syphilis.

Hæmophilia, especially in the new-born, in some instances very closely resembles purpura of the hemorrhagic kind; but in the former the presence of hereditary factors, together with the bleeding from the umbilicus, and occasional jaundice, ordinarily suffices to differentiate them.

Scurvy.—In this disease we may have extravasation of blood into the subcutaneous tissues and muscles, giving indurated, hemorrhagic spots and patches not unlike purpura, but close attention to the circumstances and previous health will throw much light upon the diagnosis. Furthermore, the swollen and bleeding gums of scorbutus are never found in the latter disease. This disease, unlike purpura, may be endemic or epidemic.

Primary Anæmia and Leukæmia, coming on acutely with hemorrhage, must not be forgotten, since only a blood examination in certain cases serves to distinguish them from purpura.

Pseudoleukæmia may, in rare cases, present even greater difficulties, and can be certainly diagnosed only in the presence of enlarged spleen and lymph nodes.

Rheumatism, when accompanied by a hemorrhagic skin eruption, bears only a superficial resemblance to hemorrhagic purpura. In rheumatism there are, as a rule, higher fever, profuse sweats, much more marked pains in the joints, which move with greater frequency from one joint to another, considerable exudation into the joints, and more common association of cardiac complications.

Erythema of the exudative type, if causing ecchymoses, gives a picture suggestive of purpura; but the color of the skin, being due to congestion in the blood-vessels, disappears with pressure, to return when the pressure is removed.

Malignant Endocarditis can be readily distinguished by the presence of cardiac lesions.

Treatment.—For primary purpura, no treatment has given very satisfactory results. Rest in bed for a long period is desirable in all cases, and essential in severe forms, since the prolonged rest seems to lessen the chances of relapse as well as the severity of the attack. Mental activity, excitement, overwork, exposure to cold, and trauma of the skin must be provided against. The sick-room should be cool, the diet light and nutritious, and without stimulants of any kind. Acid drinks may be of advantage. If there is any tendency to constipation, mild cathartics, such as castor oil and cascara, or enemata, may be employed to advantage. Of considerable help are warm baths to which chlorides or carbonates have been added.

Of drugs, turpentine, according to McKenzie, is the most reliable remedy. When the coagulability of the blood is much diminished, Wright recommends the use of calcium chloride in twenty-grain doses, and claims to have seen excellent results following its use. Werlhof claims to have found in sulphuric acid a specific. When the bleeding has been marked, ergot, acetate of lead, tannic acid and gallic acid in a few instances appear to have been of service. Osler and others advise the use of Fowler's solution given to the limit of tolerance. In cases of Schönlein's disease, the salicylate compounds appear beneficial, but give no such results as in rheumatism, and must be used with care. If collapse should occur the usual treatment by stimulants, by the employment of heat, or by injections of decinormal saline solution, should be adopted.

After-care demands a carefully regulated diet and a quiet life in the open air. Tonics may be employed if indicated, also iron and arsenic in the presence of anæmia. With the slightest tendency to a return of the purpuric symptoms, it is imperative that the patient should return to bed.

An examination of the urine should be made from time to time for a considerable period, since albumin has been known to appear even after the lapse of months, and in some cases a chronic nephritis has developed.

Edwin Allen Locke.

MORPHINE.—*Morphina* ($C_{17}H_{19}NO_3 + H_2O = 302.34$). An alkaloid obtained from opium.

Origin.—Morphine is of great interest as being the first alkaloid ever discovered and probably of more medicinal importance than any other article of the materia medica. Its origin and occurrence are fully discussed under the title *Opium*. Its occurrence in the vegetable kingdom elsewhere than in the poppy capsule is not positively proven, but it is probable that it exists in minute amount in the milk juice of Argemone. Its preparation consists essentially in repeated macerations of the opium in distilled water, by which the morphine salts are dissolved out, filtering the solution, and adding alcohol and ammonia water, by which latter the salts are decomposed and the morphine is precipitated. The resulting crystals contain more or less impurities, consisting of other alkaloids, coloring matter, etc., and require repeated purification processes.

Description and Tests.—Colorless or white, shining, prismatic crystals, or fine needles, or a crystalline powder, odorless, and having a bitter taste; permanent in the air.

Soluble, at 15° C. (59° F.), in 4,350 parts of water, and in 300 parts of alcohol; in 455 parts of boiling water, and in 36 parts of boiling alcohol; also soluble in 4,000 parts of ether.

When heated to about 75° C. (167° F.), morphine begins to lose its water of crystallization. Heated for some time at 100° C. (212° F.), it becomes anhydrous. At 254° C. (489° F.) it melts, forming a black liquid. Upon ignition, it is consumed without leaving a residue.

Morphine has an alkaline reaction upon litmus paper.

When crystals of morphine are sprinkled upon nitric acid (specific gravity 1.250 to 1.300), they will assume an orange-red color, and then produce a reddish solution gradually changing to yellow.

On shaking a small portion of morphine, in a test tube, with 10 c.c. of chlorine water, the latter will acquire a yellowish color. On now carefully pouring a small amount of ammonia water on the surface of the liquid, a brown or reddish-brown zone will form at the line of contact of the two liquids.

If to a neutral one-per-cent. solution of morphine, made by the careful addition of dilute sulphuric acid, a few drops of ferric chloride T. S. be added, a blue color will be produced which is destroyed by acids, alcohol, or heating.

On treating morphine with cold, concentrated sulphuric acid free from nitric acid, the liquid should not at once acquire more than a faintly yellowish tinge (absence of more than traces of *narcotine*, *papaverine*, etc.); and the subsequent addition of a small crystal of potassium permanganate should produce only a greenish, but no violet or purple, color (difference from *strychnine*).

On precipitating a solution of any of the salts of morphine by ammonia water, dissolving the washed precipitate in sodium hydrate T. S., shaking the solution with an equal volume of ether, and evaporating the ethereal solu-

tion, no appreciable residue should remain (absence of *narcotine*, *codeine*, etc.).

On adding 4 c.c. of potassium or sodium hydrate T. S. to 0.2 gm. of morphine, a clear, colorless solution, free from any undissolved residue, should result (absence of, and difference from, *various other alkaloids*).

Actions and Uses.—In a general and brief way, morphine may be described as the typical somnifacient and general analgesic, with moderate locally analgesic powers also, a depressor of the motor spinal centres, an inhibitor of the pulse, a paralyzer of the respiration, a mild antipyretic, and an inhibitor of general metabolism and of all secretions and excretions excepting the perspiration. The ordinary effects upon man are as follows, and occur in nine-tenths or more of those who take it: A short spell of conscious comfort and good feeling; freedom of thought; bodily and mental calm; a warm, pleasant, slightly numb feeling, especially in the finger tips and toes; absence of hunger; slight dizziness and absent-mindedness; dryish tongue; indifference to slight annoyances and discomforts; diminished pupils; sleepiness, and, if yielded to, sleep. Upon waking, if the dose is an ordinary medical one, more or less uncomfortableness, slight nausea or aversion to food, dry tongue, and the omission of the next regular stool. There is probably an undercurrent of each of the other classes of effects in every case, but in a typical one like the above they are so entirely overshadowed by the brain stupor as to be unnoticeable.

The specific effects of morphine may be described as follows:

Absorption, Circulation, and Elimination.—Morphine is readily absorbed from the stomach, slightly less quickly from the rectum, more slowly from the vagina, very little from the skin, and almost not at all from the bladder. From the air passages, administered in spray or powder, enough is absorbed for local effect, and but little more; from abraded surfaces and granulations absorption is irregular, and may be too little to be of any benefit, or, on the other hand, too much for safety. From subcutaneous injections it is diffused with great regularity and effectiveness. In man, the usual time of absorption of a medicinal dose is as follows: By the stomach, empty or in active condition, the first symptoms appear in fifteen or twenty minutes, the full effect in, say, an hour; by the rectum, one must allow from one and one-half to twice as long, and about one-third larger dose for the same results; by the vagina, at least twice the time and twice the dose for any general effect; by the skin, only local results can be looked for. Hypodermatically, the first effects are generally felt in from three to five minutes, and the full influence in from fifteen to thirty. In the system it circulates as morphine, and a certain amount of it (what portion is not definitely known and probably varies under different conditions) is so eliminated. It is believed to be chiefly eliminated in the urine, as a result of which poisoning is readily induced when, for any reason, this channel of elimination is inactive. It is now known that much of it is excreted into the stomach and intestines, a varying portion of which is liable to be again absorbed. Advantage is taken of this fact, in opium poisoning, to destroy the morphine, by various methods, as the successive portions thus enter these organs. An appreciable amount is excreted by the liver and appears in the bile, and another small portion may make its appearance in the perspiration. In nursing mothers, morphine is very apt to make its appearance in the milk, and fatal cases of poisoning of infants have thus occurred. The question of the oxidation of morphine in the system, to any appreciable extent, is an open one, though this method of destruction in the stomach, in cases of poisoning, by the use of such agents as potassium permanganate, is thoroughly established. Owing to the action of the drug in checking those excretions upon which its elimination depends, poisoning is especially liable to result, through accumulation in the system, and this highly important fact should ever be borne in mind during its prolonged administration. The doses should not be brought so close together as to fail in affording sufficient time upon the one hand for elimination and upon the other for tolerance to be established.

Idiosyncrasy.—Great variation is observed among individuals as to the effects produced upon them by morphine. In almost all cases, except when large doses are introduced suddenly into the circulation, it is possible to observe a primary stage of excitation before that of depression comes on, and it is in this direction that the differences referred to are most plainly visible. In very sensitive subjects, or those in whom control is less perfect, this primary stage may border on intoxication, being accompanied by a mildly convulsive condition of the spinal centres. In the after-effects of the drug, idiosyncrasy again strongly asserts itself, one subject waking refreshed and with but slight disagreeable sensations, while another suffers from headache, nausea, and general malaise. Itching is a frequent symptom and becomes extreme in some individuals. Again, the intestinal effect differs greatly in different persons, differences which can be understood only through a knowledge of the mechanism of the action of the drug upon this part of the system.

The action of morphine in inducing constipation is the effect of depression of the motor functions; yet it is possible for large doses to paralyze the inhibitory power of the splanchnic nerves, thus permitting increased peristalsis, with a laxative result. Thus has been explained the effect of opium in overcoming the constipation of lead colic, in which condition such inhibition is excessive. The somnifacient effect of opium is to be explained by its direct depressing effect upon the centres, in which the order of effects proceeds regularly from the higher to the lower faculties. It is customary to think of the existence of a primary stage of stimulation as accounting for the early symptoms of exhilaration; but it is doubtful if this be not merely a manifestation of the first stage of depression, affecting the cerebral inhibitory powers. How morphine acts in inducing a powerful and extreme contraction of the pupil is uncertain. Most physiologists are inclined to charge it to stimulation; but it is more in line with its known effects in other directions to regard it as the result of inhibitory depression.

The primary cause of the diminished secretions resulting from the action of morphine is believed to be a depression of the secreting centres.

The action of morphine upon the circulation, and more especially upon the respiration, and in other ways than those mentioned above, is more conveniently considered in connection with the toxicology of the subject.

Therapeutical Uses.—Among all the uses of morphine that of relieving pain undoubtedly stands at the head. There is no form of pain which cannot be relieved or wholly removed by its use, nor in which it may not be employed, subject of course to special contraindications. In this line may be cited its use as an anodyne in relieving an irritable cough. Although the modern use of codeine, heroine, etc., has to a great extent taken its place, morphine is still largely used and is of great value in such cases. It also gives great relief in pleurisy, although its employment should here be accompanied by great caution since it favors the formation of adhesions. Many cases of vomiting are relieved by morphine, even when the seat of the irritation is not directly in the stomach.

Morphine is of the greatest value in the treatment of peritonitis and other abdominal inflammations, though opium is here to be preferred, as elsewhere stated.

It is frequently of great value in surgical operations, not only to relieve the patient and afford sleep after the operation, but, with or without other anæsthetics, to deaden sensation as a preliminary thereto.

As a diaphoretic morphine is not a good agent, opium, especially in connection with other drugs, being preferable.

Morphine is a valuable supporter of the system, both in acute cases in overcoming shock, and in the exhaustion of disease, although its depressing effect upon the

heart must here be reckoned with. Even in diseases of the heart itself, great benefit is sometimes to be derived through the rest afforded.

Its use in insomnia is subject to the very great risk of establishing the opium habit. Even when the insomnia is but temporary, the exceedingly pleasant results are liable to lead to its use upon similar future occasions, and the temptation is most insidious.

Other uses of morphine, for which opium itself is more appropriate, will be considered under the latter title.

Compounds, Preparations, and Doses.—Morphine is rarely used in the pure state, since one may obtain numerous salts which are far more soluble and absorbable than itself. Its ordinary dose is 0.008 to 0.015 gm. (gr. $\frac{1}{8}$ to $\frac{1}{4}$). This dose, however, as well as those of its salts, is subject to a degree of variation scarcely equalled in any other drug. Children are far more susceptible than adults, women are distinctly more susceptible than men, and there is a great difference among the latter, depending upon temperament. The effect of the drug is directly counteracted by pain or excitement, and large quantities must frequently be given to overcome the former. Tolerance is quickly established, and under it, or under the influence of habit, the production of medicinal effects demands a great increase in the dose.

The acetate (*Morphinæ Acetas*—$C_{17}H_{19}NO_3C_2H_4O_2 + 3H_2O = 398.12$) is white or faintly yellowish, crystalline or powdery, has a faint odor of acetic acid and a bitter taste, is soluble in 2.5 parts of water, 47.6 of alcohol, 1,700 of ether, and 2,100 of chloroform. Upon exposure, it gradually loses its acetic acid and becomes less soluble.

The hydrochlorate (*Morphinæ Hydrochloras*—$C_{17}H_{19}NO_3HCl + 3H_2O = 374.63$) occurs in a white feathery silky mass of fine acicular crystals or in minute cubical crystals, which are bitter and permanent, soluble in 24 parts of water, 62 of alcohol, and very little in ether or water chloroform. It is neutral.

The sulphate (*Morphinæ Sulphas*—$[C_{17}H_{19}NO_3]_2H_2SO_4 + 5H_2O = 756.38$) presents an appearance similar to that of the hydrochlorate, but dissolves in 21 parts of and 702 of alcohol.

The doses of these salts are about the same as those of morphine, and they are, especially the acetate, because of its high solubility, readily available for hypodermatic use. The official preparations are wholly of the sulphate. The compound morphine powder or Tully's powder (*Pulvis Morphinæ Compositus*) has a strength of one part of the sulphate of morphine in sixty, the remainder being nineteen of camphor, twenty of powdered liquorice, and twenty of precipitated calcium carbonate. The dose is 0.3 to 1 gm. (gr. v.–xv.). The troches of morphine and ipecac (*Trochisci Morphinæ et Ipecacuanhæ*) each contain 0.0016 gm. (gr. $\frac{1}{40}$) of morphine sulphate, with about three times as much powdered ipecac, mixed with sugar, mucilage of tragacanth, and a little oil of wintergreen to flavor. The dose is one to five troches. The *Liquor Morphinæ Sulphatis* is made by dissolving thirty-five grains of morphine sulphate in two fluidounces of alcohol and about six fluidounces of distilled water, so that it has a strength of about half a grain of morphine sulphate to the fluidrachm. The dose is fl. ʒ ss.–i. The Magendie's solution is somewhat similar, but contains sixteen grains of morphine sulphate to the fluidounce, or two grains to the fluidrachm, thus four times as strong as the last; the dose is ♏v. to xv. There is still another Liquor Morphinæ Sulphatis, of an earlier pharmacopœia, containing one grain to the fluidounce. Because of these wide differences in strength, it is not advisable to prescribe this solution by name without specifying the strength.

Henry H. Rusby.

MORPHŒA—(Gr. μορφή, form, shape); keloid of Addison; circumscribed scleroderma)—is a disease of the skin characterized by the presence of variously sized, round, oval, or band-like patches, violaceous, white, yellowish-white, or brown in color, situated on various parts of the cutaneous surface, without definite arrangement or, less frequently, distributed along the course of some nerve. These patches vary in size from a small pea to the palm of the hand and even larger, are sharply circumscribed, and are usually surrounded by a pink or lilac-colored border, of variable width, which is composed of minute blood-vessels. They may project slightly above the surrounding normal skin or be on a level with it; they are firm and inelastic to the touch, smooth, and shining, presenting an appearance, when the patches are white, which has been aptly compared to old ivory. In patches which have existed for some time there may be moderate scaling, or the centre may be occupied by a number of small pit-like depressions looking like the dilated mouths of the ducts of sebaceous glands, with which, however, they have no connection. The number of lesions present varies from a single one to a half-dozen or more, but is rarely considerable. While no part of the skin is exempt, the disease shows a predilection for certain regions, the parts most commonly affected being the face, the breasts in women, the arms, and the thighs. When the lesions assume a zosteriform arrangement they occur most frequently over the branches of the fifth pair, in the course of some of the branches of the brachial plexus, over the intercostals, or down the thigh. As a rule, subjective symptoms are rarely marked and are often entirely wanting. There may be slight itching, tingling or burning, and in a small number of cases more or less severe neuralgic pains.

The malady is a chronic one and its course is apt to be extremely irregular. After gradually increasing in size for a time the patches may remain unchanged for months or years, and then slowly and almost imperceptibly the skin may resume its normal condition. On the other hand, the skin may become thin, shrivelled, and scaling, adherent to the parts beneath, assuming, particularly in the case of the band-like patches, the appearance of deep scars. When such an atrophic process occurs in patches situated in the neighborhood of joints motion may be more or less seriously interfered with.

Morphœa is seen much more frequently in women than in men. Age is apparently without influence. Long-continued irritation of the skin, such as may result from the pressure of a garter or the rubbing of the stays, a blow, or an injury to a nerve, have seemed to be the exciting cause in some cases. In the great majority of cases, however, no satisfactory explanation of the occurrence of the disease can be given.

PATHOLOGY.—Although the exact nature of the malady is not yet definitely determined, there is much in favor of the view that it is a trophoneurosis. Its frequent occurrence in neurotic subjects, the arrangement of the patches over the course of some nerve, and the neuralgic pains which accompany it in a certain proportion of cases are some of the features which lend probability to the neurotic theory of its origin.

The tissue changes characteristic of the affection are found almost exclusively in the corium, the epidermis being little if at all affected. The papillary layer is markedly flattened, and its blood-vessels are greatly narrowed and even in places obliterated. About the vessels of the deeper parts of the corium there is a round-cell exudate which produces narrowing of their lumen and occasional thrombosis. According to Unna the elastic fibres are unchanged, but there is an hypertrophy of the collagenous tissues. About the margins of the sclerosed areas there are numerous dilated vessels—the result of a collateral hyperæmia—which give rise to the peculiar lilac-colored border about the patches. The sebaceous and sweat glands are more or less atrophied, the result of the pressure from the hypertrophied fibrous tissues.

DIAGNOSIS.—Well-developed morphœa presents such marked and peculiar features that there is seldom any difficulty in its diagnosis. The smooth, ivory-like patches surrounded by a violet border are quite unlike any other disease of the skin.

In the white patches of vitiligo, which only remotely resemble those of morphœa, there is simple loss of pigment without any structural alteration of the skin.

PROGNOSIS.—In cases of moderate extent and severity the prognosis is usually fairly favorable. In the majority of cases, after a duration of some months, or it may be two or three years, the skin gradually resumes its normal aspect. When, however, marked atrophy has taken place with adhesion to the deeper structures, forming scar-like patches, the prognosis is extremely unfavorable.

TREATMENT.—Treatment is rather unsatisfactory. Internally such remedies as cod-liver oil, arsenic, quinine, and iron may be administered with the view of improving the patient's general health. Thyroid extract has been given with asserted good results in a small number of cases. Locally, frictions with bland oils and fats are useful, and so also are mild galvanic currents applied, as Crocker suggests, in the neighborhood of, rather than directly to, the patches, to avoid any possible irritant effect. Brocq recommends electrolysis, employed as in the removal of hairs. The needle should be inserted in every portion of the patch, the current used varying from 8 to 15 milliampères, and the needle should be allowed to remain fifteen seconds at each puncture. Between the sittings mercurial plaster is to be applied. Hebra has obtained good results from intramuscular injections of a fifteen-per-cent. alcoholic solution of thiosinamin, half a Pravaz syringeful of the solution being injected every second day. *Milton B. Hartzell.*

MORRISON SPRINGS.—Jefferson County, Colorado.

POST-OFFICE.—Morrison. Hotel recently built.

ACCESS.—From Denver viâ Denver, Gunnison, and Leadville Railroad. Morrison Springs are located fourteen miles southwest from Denver, in the basin of Bear Creek and just within the Rocky Mountain foothills at an altitude of six thousand feet above the sea level. No complete quantitative analysis of the waters seems to have been made, but Dr. W. C. McNeal, of Morrison, furnishes us the following report of a partial qualitative examination:

Sulphureted hydrogen.	Iron.
Calcium bicarbonate.	Magnesium sulphate (forty grains per gallon).
Manganese.	Potassium (trace).
Sulphuric acid } Doubtless in	
Arsenious acid } combination.	

Temperature of water, 80° F.

This incomplete analysis would indicate that the waters possess tonic, laxative, and alterative properties. They are recommended in renal, digestive, skin, and rheumatic affections, and in chronic syphilis. *James K. Crook.*

MORTALITY. See *Vital Statistics*.

MORVAN'S DISEASE; ANALGIC PANARITIUM.—This curious and extraordinarily rare disease was first described by Morvan, of Brittany, in 1883. In applying the name analgic panaritium, or "painless whitlows," Morvan was obviously more influenced by the salient clinical feature of the disease than by any consideration for its underlying pathology. Viewed in the light of the more critical tendencies of recent years, the desirability of retaining it as a clinical entity, to the burden of an already overcrowded neurological nosology, seems more than doubtful.

The opportunities for investigating the disease, even in the services of large hospitals, are so meagre that little or no satisfactory advance has been made in our exact understanding of its genesis and morbid sub-structure. It appears to consist of a syringomyelic condition—or of the associated gliomatosis—plus a peripheral neuritis.

In the few cases in which a microscopic examination of the cord has been made, the connective-tissue overgrowth appeared in the posterior part of the gray matter and in the posterior columns.

It is practically certain that syringomyelia takes its origin in a developmental defect. As the primary morbid condition of the disease under consideration is analogous to that of syringomyelia in all essential details, it seems to the writer much more reasonable to regard the extra feature of Morvan's disease, the peripheral neuritis, of identical origin. This point of view makes the two morbid processes practically alike in all respects except topography, and the doubt arises as to whether this single feature of dissimilarity is sufficient to establish Morvan's disease on the plane of a clinical entity. Repeated observations of the apparent fortuitousness of the morbid distribution in cases of other developmental defects should tend, by analogy, to reduce the present distinguishing features of syringomyelia and what we now term Morvan's disease to the vanishing point, and such a result is desirable for obvious reasons.

As the clinical features of the two diseases now stand, there is nothing upon which we may rely absolutely for differentiation between them. Both are apt to give the first clinical manifestations of their presence in the first half of adult life, and both are alleged to follow some traumatism or to arise in consequence of abuse of function. How important local traumatism may be in the production of Morvan's disease it is difficult to say, owing to the natural rarity of the affection. It probably has about as much etiologic value, however, as that other frequently alleged causative agent in nervous diseases—exposure to cold and wet.

In Morvan's disease the symptoms begin as a rule in the upper extremities. Of these the most striking are the whitlows, which are usually, though not invariably, painless, owing to the loss of all forms of sensation preceding them. With the whitlows there may be recurring ulcerations on various parts of the fingers. These ulcers are deep and not unlike the perforating variety observed in tabes. They are accompanied by cracks in the skin, and the nails shrivel and split. Although the occurrence of the whitlows is the striking feature of the disease, it is not the most important or serious. As has been said, they occur as a rule subsequently to the abolition of all forms of sensation, but they have important precursors in the form of muscular weakness and wasting in the hands and forearms. Although the trophic mischief is practically limited to the hands, and the muscular wasting does not go above the forearms, the sensory loss may involve the entire arms, parts of the trunk, and even the face. Sufficient vaso-motor derangement to cause lividity and pallor of the skin often precedes and accompanies the nutritional disturbance. An affection of the shoulder-joint has been noted. When the ulcerations of the fingers involve the terminal phalanges, the latter may be entirely destroyed. The electrical irritability of the nerves involved in the affected parts pursues variations, as the disease progresses, similar to those observed in the progressive atrophies of spinal origin, a gradually increasing quantitative loss, followed by inversion of the formula. The feet are rarely the seat of the painless ulceration; although the legs may be weak and the knee-jerks exaggerated, owing probably to the partial implication of the nutritional arteries of the lateral columns in the overgrowth of tissue. The course of the disease is extremely slow, extending over many years. In certain cases it has appeared to be arrested.

In the matter of differential diagnosis there are no particular difficulties except in regard to syringomyelia. Here, in the opinion of the writer, there is no absolute distinction. For certain authorities the retention of tactile sensibility and the absence of the whitlows are sufficient to rule out Morvan's disease in a doubtful case. In Raynaud's disease the vaso-motor disturbance is paramount and the loss of sensibility, when it exists, is not alike in kind or degree. In sclerodactyla there are no sensory loss and no tendency to destructive ulceration of the finger ends. In anæsthetic leprosy there are no ulcerations whatever, while there is a tendency to pigmentary deposit in the skin areas involved.

Owing to the nature of the malady, the question of treatment is easily settled. No drugs are specifically indicated. Even symptomatic treatment is of little importance because of the practically painless course which the disease pursues. Iron, arsenic, and strychnine are among the drugs used, but it is more than doubtful if they have exerted other than a general effect.

Joseph William Courtney.

MOSQUITOES IN RELATION TO HUMAN PATHOLOGY.—The special importance of the mosquito as an agent in the transmission of disease has been thoroughly demonstrated by recent discoveries, a brief synopsis of which may be given as an introduction to the subject.

HISTORY.—In 1880 Manson, by establishing the connection of mosquitoes with elephantiasis, gave the first demonstration of their culpability in spreading disease. It was the same year (1880) that Laveran discovered the intraglobular parasites now universally acknowledged as the cause of malaria. The transference of these hæmatozoa from one host to another by means of mosquitoes was conjectured as early as 1883 by King and in the following year by Koch and Laveran; but was first actually demonstrated by Ross, in a series of experiments between 1895 and 1899; these facts have been abundantly confirmed by many subsequent investigators. In 1897 MacCallum first observed the sexual phase in the allied avian hæmatozoa, and the further elucidation of the life history of the parasite was brought about by contributions of Ross, Bastianelli, Bignami, Grassi, and others, while unimpeachable evidence of the agency of the mosquito in carrying the disease was furnished by the positive infection experiments of Manson, who imported from Rome tertian infected *Anopheles*, which evoked the disease in those whom they were permitted to bite in London.

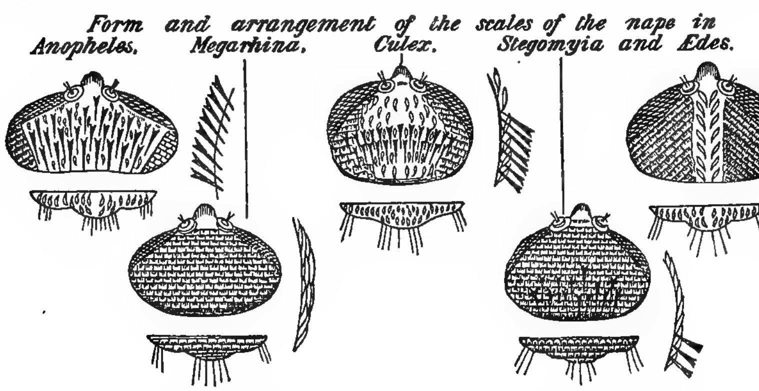

FIG. 3363.—Graphic Key to Scale Arrangement of Leading Genera. (After Giles.)

The connection of the mosquito with yellow fever, conjectured by Finlay of Havana as early as 1881, waited until 1900 for its experimental demonstration in the investigations of the Yellow Fever Commission, consisting of Drs. Reed, Carroll, Lazear, and Agramonte, in the course of which two members of the Commission acquired the disease and one, Dr. Lazear, succumbed to it.

Kinds of Mosquitoes.—It is necessary now to consider the various types of mosquitoes before taking up more specifically their relations to disease. In all about three hundred species of mosquitoes have been described, of which only thirty-six species have been recorded in North America. Of these five belong to the genus *Anopheles*, three to *Stegomyia*, and no less than eighteen to *Culex*. It would be impossible within the limits of an article even to outline the complete classification of the group, but some of the most important facts may be stated briefly. The order and family have been sufficiently characterized by Professor Osborn (see *Insects*). It is extremely uniform in character, and only recently has Theobald found a basis for subdivision in the form and arrangement of the scales on the body and wings. His classification with some additions suggested by Giles is followed here. The sub-families are distinguished as follows:

Section A. Proboscis formed for piercing.

I. Brilliantly colored insects with a very long, curved proboscis.

(*a*) Palpi, about as long as the proboscis in both sexes (*Megarhina*); or long in male, shorter in female (*Toxorhynchites*). *Megarhinina.*

II. Dull-tinted insects with straight proboscis.

(*b*) Palpi about as long as the proboscis in both sexes: those of the male clubbed at the end, those of the female linear. *Anophelina.*

(*c*) Palpi about the length of the proboscis in the male but much shorter in the female, being here usually very short. *Culicina.*

(*d*) Palpi very short in both sexes. *Ædomina.*

Section B. Mouth parts not formed for piercing, there being no true proboscis. Palpi small. *Corethrina.*

For the determination of the genera the form and arrangement of the scales, which are all-important, are shown diagrammatically in the figure (Fig. 3363). So far as the species are concerned, it is impracticable to make more than a preliminary determination without referring to a monograph, and there will be mentioned only a few of the more important forms, in those genera which are now known to be responsible for the transmission of disease. A few hints as to methods of collecting and examining will doubtless be useful to the practitioner. The adult mosquitoes are very delicate, so that the parts are easily broken and the arrangement of the scales easily obscured by rough handling. The female may be readily caught on the hand or arm when biting, or even on the wall of a room, by inverting an ordinary vial over it; once trapped a whiff of tobacco smoke or a drop of chloroform will kill it immediately and leave the specimen in good condition for examination or transportation on cotton in a pill box. A good killing vial may be made by confining a small piece of cyanide of potassium at the bottom of a shell vial by a disc of blotting paper cut to fit the vial. After it has been inverted over the mosquito, the cork may be slipped into the mouth of the vial and the insect succumbs almost instantly and without damage. Mosquitoes may be mounted dry on pieces of thin card or cork, but should not be enclosed in balsam as this destroys colors and renders identification difficult. Most of the characters can be determined with a triplet; all with the low power of a compound microscope.

For collecting larvæ, which are often difficult to distinguish against the dark background in a pool, a white cup is useful; or a coffee strainer may be drawn through the vegetation at the margin of a pond or stream and the material obtained may be examined more carefully in a cup of water or on a white plate. Larvæ may be bred in jars, which should be covered with mosquito netting to prevent the escape of the adults when they emerge, while the latter may be kept in frames of netting, but should be provided with a little water and pieces of banana or dates on which they feed. If desired larvæ may also be preserved in dilute formalin or in alcohol. Further data may be found in any of the manuals cited.

Anopheles Meigen (1818).

Head with both flat and narrow curved scales, but mainly covered with large upright forked scales; palpi long in both sexes, usually about the length of the proboscis, four-jointed in the female, three-jointed in the male, in which the last two joints are short and thick; constrictions at the base make the palpi possess apparently one or two extra joints in each sex. Antennæ, fourteen-jointed, filiform, pilose in the female, fifteen-jointed and plumose in the male.

Thorax sometimes nude on the dorsum, usually with narrow curved or small spindle-shaped flat scales. Abdomen generally pilose, but sometimes with a few scales

and rarely with many. Wings covered with small scales of normal form or inflated, with the first submarginal cell longer and narrower than the second posterior cell; both the second and third long veins run past the cross veins into the basal cells, a very marked characteristic.

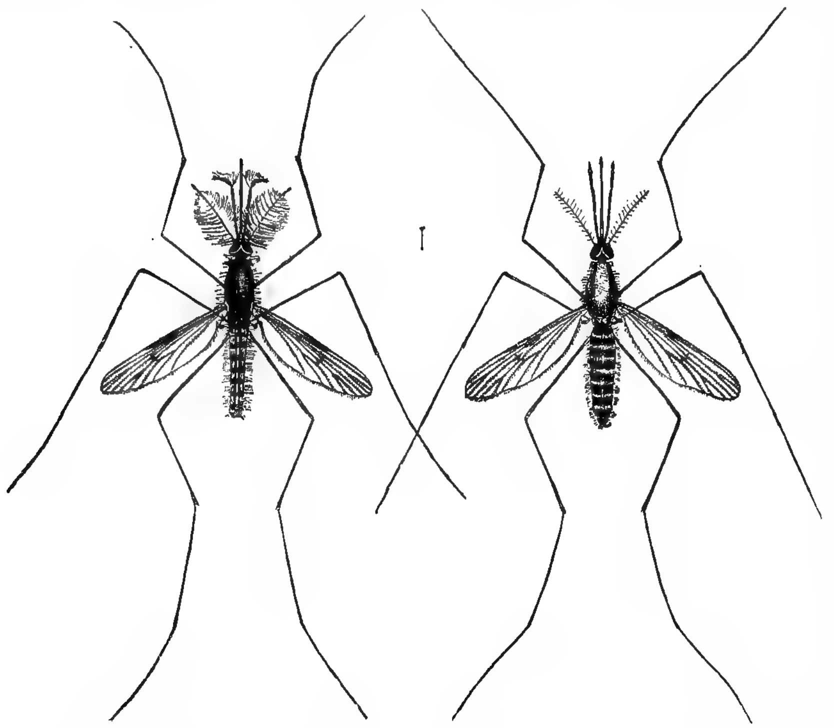

FIG. 3364.—*Anopheles maculipennis* Meig. Male at left, female at right. (After Howard, Bull. United States Dep. Ag.)

The etiological importance of this genus has been thoroughly demonstrated in its transmission of malaria, and it has also been shown to be instrumental in transmitting filiariasis. As a genus it is widely distributed, with the exception of the higher latitudes. Nuttall has shown that in England this distribution compares exactly with the old limits of ague, but the genus also occurs in districts where no ague is known to have existed. It does not follow that because *Anopheles* are found, malaria is present; but wherever the latter occurs, the presence of *Anopheles* in considerable numbers has been demonstrated. *Anopheles* is moreover accustomed to fly and to bite only after sunset, so that by keeping within well-screened houses after that hour malaria is avoided even in the worst infected localities. The bite of this genus is believed to be less irritating than that of other mosquitoes and from its habits of lurking near the ground it is less likely to be discovered. Its hum is said to be less distinct than that of *Culex* and of a lower pitch. The adults hibernate in woods, and the larvæ may be found both in fresh and in salt water, even after frost has occurred.

Anopheles punctipennis Say. Wings with the costa black, interrupted by a single large ferruginous spot a little outside the transverse veins, with also a smaller apical spot and some yellow spots near the tips of the long veins. Legs and tarsi nearly uniformly black. Thorax and abdomen deep brown, nude except for some yellowish-brown hairs; wings much longer than abdomen; head black with a scanty whitish frontal tuft, palpi and proboscis dark yellowish-brown unbanded, but rather lighter at the tips, length 5 to 7 mm.

This species is very widely distributed over our continent and is said to be called the "winter mosquito," having been taken when the temperature was only 6° F.

Anopheles maculipennis Meigen (1818) (Fig. 3364). Wings with four tufted spots on the wing field, the costa being uniformly dark except at the apex, where its color fades to form a fairly distinct spot; tarsi unbanded but with an apical yellow spot at the first joints. Thorax with four broad ferruginous stripes formed of golden hairs with the darker ground color left bare between and a tuft of large golden scales on the anterior border. Abdominal segments brown with yellowish basal markings. Anterior femora not thickened at the base. In the female the head with two patches of creamy scales divided by a central line, otherwise with black scales; a small tuft of white hairs in front and the borders of the eyes white. Male with antennæ banded, proboscis black, palpi dark brown. Length of male 4 to 7.5 mm., of the female 8 to 10 mm.

To illustrate the great variation of this species in size, Giles has drawn the wing of an Italian specimen over the wing outline of a Canadian specimen from the British Museum in a figure which is here reproduced (Fig. 3365).

The sub-family of the Culicina is the largest among the mosquitoes, and its type genus *Culex* includes more than one hundred and fifty species. In addition to the characteristics mentioned in the synopsis above it may be noted that the anterior fork cell is at least as long as the hind one. Of the dozen genera only two are noted.

Stegomyia Theobald 1901. Palpi short, four-jointed in the female; long, five-jointed in the male. Head clothed completely with an armour of broad, flat scales; mesothorax covered with either narrow curved or spindle-shaped scales. Scutellum always with broad flat scales on the middle lobe and usually also on the lateral lobes; abdomen completely covered with flat scales, banded or unbanded, but always with white lateral spots. The female palpi are small, never more than one-third the length of the proboscis; those of the male are as long as, or longer than, the proboscis. Wings of similar venation to those of *Culex*, but the fork cells are short. With hardly an exception they are colored jet black contrasted with pure white in bands and stripes on the legs and thorax, which is often elaborately adorned; in all black predominates, and they have a characteristic smooth satin-like appearance.

As these mosquitoes are rarely found north of 40° North latitude, they are characteristically tropical and subtropical forms. They are said to be good sailors and as a result *S. fasciata* belts the world with its colonies, being the most widely distributed of all mosquitoes.

FIG. 3365.—Wing of *Anopheles maculipennis*. Outer outline to show size variation. (After Giles.)

The description of this cosmopolitan species is as follows:

Stegomyia fasciata (Fabr.). Wings (Fig. 3366) densely clothed with very long black scales of three lengths. Last hind tarsal joints and all but the apex of the next snowy; all the other joints of the hind, the upper three of the mid, and the upper two of the fore legs of the otherwise black tarsi basally white banded. Thorax from a velvety black with reddish reflections to a golden brown in some specimens, elaborately marked with rather broad silvery lines arranged in the form of a lyre (Fig. 3367). First abdominal segment creamy white, the others black with narrow basal bands and brilliant lateral tufts of snowy white. Proboscis unbanded, black. Head black with narrow white orbits and two faint patches of white on the occiput divided by delicate median and lateral black lines. Of moderate size, often very small, some even with wing length not exceeding 2 mm. In some places a pure rainy weather species.

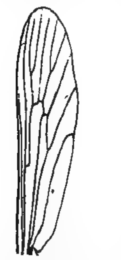

FIG. 3366.—*Stegomyia fasciata.* (After Giles.)

FIG. 3367.

The extreme variation in size and color markings has led to the frequent redescription of this form as a distinct species. Giles says that specimens hatched from the same tank vary so very widely as to render varietal limits decidedly uncertain. In the United States it is common throughout all the Southern States, having been found about as far north as Norfolk, Virginia, while its previous or occasional range as far as Philadelphia, New York, and Providence is clearly indicated in the epidemics of yellow fever at those places about the beginning of the last century. It is said to be troublesome in the early afternoon and again at night, in contradistinction to the majority of mosquitoes, which are twilight flyers. It certainly is a hardy species, and individuals infected with yellow fever have been kept alive seventy-one days, thus showing how contagion of yellow fever may cling to a building which has been vacated more than two months. According to Gorgas it breeds principally in yards in more thickly settled parts of the city, in all fresh-water collections, such as rain-water barrels.

Culex Linnæus. Palpi short, three- or four-jointed in the female, with the last joint usually large; long, three-jointed in the male with the last two joints swollen much as in *Anopheles*, or narrower with the last pointed. Antennæ fourteen-jointed; pilose in the female, plumose in the male, where the last two joints are long and thin. Head with narrow curved scales over the occiput and upright forked scales thick on the back of the head, with flat scales on the sides. Thorax with narrow, curved, hair-like or spindle-shaped scales. Scutellum with narrow curved or spindle-shaped scales only. Abdomen with flat scales. Wings (Fig. 3368) with small median scales on the veins and more or less thin linear lateral ones on some or all of the veins. In the wings the first submarginal cell is longer and narrower than the second posterior cell, and the posterior cross vein is always nearer the base of the wing than the mid-cross vein.

The extreme number of species included within this genus makes it difficult to find one's way even with the aid of a monograph. Here only a few of the most characteristic forms may be briefly mentioned. So far as is known *Culex* is responsible for the transmission to man of filarial disease only, although avian malaria is certainly transmitted by members of this genus. Experiments have shown that it is not concerned in the transmission of human malaria. The salt-water or ring-legged mosquito of the Atlantic coast, *Culex solicitans*, is a small gray mosquito with the legs banded in black and white. It breeds abundantly in the brackish swamps of the eastern coast from Florida to Maine. The larvæ may be found where the water carries one-fourth more salt than the sea, but it will not breed in fresh water. According to Smith it swarms twenty miles inland and is found occasionally as far as forty miles from its breeding place.

Culex pungens (Fig. 3369) is one of the most abundant and widely distributed species in the United States. It breeds in fresh water exclusively, and its larvæ are common in water barrels, cisterns, hollows in trees, and stumps, in city gutters as well as in transient pools, and in fresh-water swamps. In Havana, Gorgas found it breeding abundantly in cesspools and drains. Its life cycle occupies in summer a minimum of ten days, but its larvæ may live over winter, and adults have been reared from such larvæ found frozen in the ice. Further details regarding the genus and some other species of *Culex* may be found under *Insects*.

Structure and Habits.—Mention should be made of such structural features and such habits as are of special importance in the transmission of disease. The highly modified mouth parts of the mosquito are arranged for piercing and sucking. They consist of the upper lip or labrum (*a*, Fig. 3370) in the form of a long narrow spine, grooved ventrally and terminating in a sharp point, the still more slender lancet-like mandibles (*b*) and maxillæ (*w*) which lie one of each on either side of the hypopharynx (*k*), the latter having the form of a delicate blade through the central thickening of which runs a minute canal, and finally the lower lip or labium (*c*) which is merely a sheath for the other parts. Giles gives a most vivid description of these structures as follows: "Imagine a surgeon's 'director,' with a piece of thin drainage tube carried against its groove, and with four slender bistouries grouped round it, and you will have a fair working model of the malaria-inoculating apparatus of the mosquito." The upper lip bears at its base a bulb in which are muscle fibres serving as extensors and retractors. Its groove forms somewhat more than a semicircle, and is converted into a complete canal by the flattened hypopharynx lying just below; it is through this canal that blood flows into the mouth cavity. The delicate tube noted above, as piercing the hypopharynx, is the continuation of the salivary duct and through it the salivary secretion, with the "sickle spores" or sporozoites of the malarial parasites, is injected into the vertebrate host, while at the same time the blood of this host is flowing back through the labrum into the digestive cavity of the mosquito. In biting, the mandibles and maxillæ appear to cut a passage through the skin by the thrust of the head and the labrum is forced into the opening thus made, while the flexible labium holds together and directs the other parts, its stem being looped down out of the way as the latter proceeds deeper and deeper into the skin.

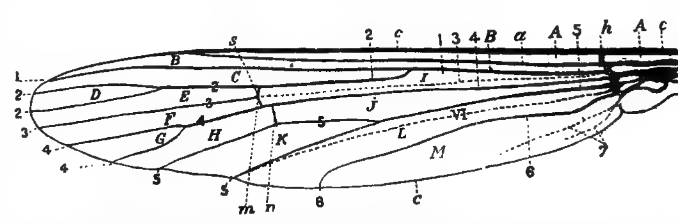

FIG. 3368.—Wing of *Culex concolor* (male) to illustrate Terminology. *c*, Costa; *a*, auxiliary vein; 1-6, first to sixth longitudinal veins and branches; 7, seventh or false (unscaled) longitudinal vein; *VI*, unscaled vein between fifth and sixth longitudinal veins; *h*, humeral transverse vein; *s*, supernumerary transverse vein; *m*, middle transverse vein; *p*, posterior transverse vein; *A*, costal cells; *B*, subcostal cells; *C*, marginal cell; *D*, anterior fork cell or first submarginal cell; *E*, second submarginal cell; *F*, first posterior cell; *G*, hinder fork or second posterior cell; *H*, third posterior cell; *I*, first basal cell; *J*, second basal cell; *K*, anal cell; *L*, axillary cell; *M*, spurius cell.

The course taken by the spores of the malarial parasite in reaching the new host can be reasonably set down about as outlined above; with the embryonic filariæ,

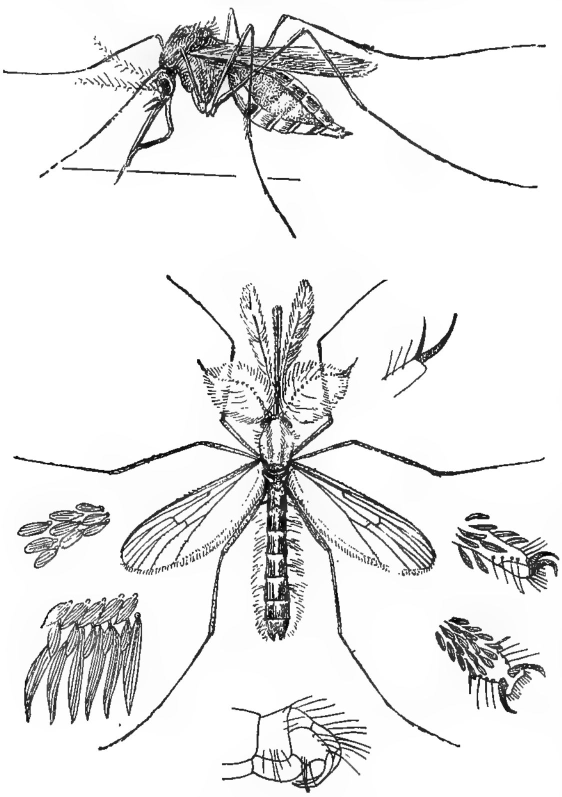

FIG. 3369.—*Culex pungens.* Female above, male below. Enlarged. (After Howard, Bull. United States Dep. Ag.)

however, the case is different and much less satisfactorily explained. These worms are known to bore their way out from the stomach of the mosquito into the muscles and thence through the connective tissue and lymph spaces through which they penetrate, even into the labium which possesses a considerable amount of suitable tissue. Here, in the opinion of Grassi, they produce swelling, and when the organ is sharply bent in biting the delicate covering is ruptured and the worms are set free, to find their way along the mouth parts and into the tissues of the new host. Bancroft maintains that the embryos of *Filaria immitis* always escape at the extreme tip of the labium as if a natural orifice existed there. On the other hand, the investigations of Kellogg in Samoa seem to show that the embryos of *Filaria Bancrofti* (= *F. sanguinis hominis*) are liberated from mosquitoes which die and fall into pools of water, and are taken up by the natives in drinking from these pools.

The organism which produces yellow fever has not yet been discovered, and all statements regarding the precise mode of introduction into man by the mosquito are purely conjecture. The interval of twelve days or more which, according to the investigations of the Yellow Fever Commission, must intervene after contamination before the mosquito can carry the infection, shows clearly that the organism of the disease is not merely adherent to the mouth parts of the insect but enters its body and undergoes some part of its life history within the tissues, at the termination of which only is it in condition for transference to a new human host. In many ways it recalls the case of malarial parasites and a similar method of transference appears probable.

In other cases in which the mosquito acts as a supposed transmitter of diseased germs, the occurrence is more probably only a passive carrying, from one human host to another, of the germs which chance to adhere to the mouth parts. The case cited by Giles and mentioned more in detail below seems to fall into this class.

Though some species are active and annoying during the day, adult mosquitoes are generally nocturnal or twilight flyers, shunning the direct rays of the sun, which they cannot endure even for a short period. They hibernate in warm, dark places, and may be found in barns, cellars, and other out-of-the-way spots during the winter. During cool days in summer they do not feed, and their abundance and virulence are clearly related to rainfall and temperature. The natural food of all species is probably plant juices, and the male with rare exceptions does not go beyond this. For experimental purposes banana or dates constitute the most acceptable food articles. Even to the female, however, a meal of blood does not seem to be essential to reproduction in spite of the efforts made to obtain it. It was formerly believed that a female mosquito, after having had a single meal of blood, laid her eggs and then died. Several investigators have recently found that she may survive and bite again either before or after oviposition. It is this occurrence which inoculates man with malaria or yellow fever germs or filariæ.

When resting all mosquitoes support themselves on four legs, the last two being held waving in the air; but the posture of the body is sufficiently different to distinguish most forms of the two common genera. *Culex* stands with a noticeable hump, the head and mouth parts forming a decided angle with the thorax and abdomen, which moreover droops, while in *Anopheles* these regions form a single straight line which is oblique or even vertical to the surface on which the mosquito is resting. So far as known, this characteristic attitude has but a single exception (*Anopheles culicifacies* Giles), a species foreign to this continent.

Life History.—The female mosquitoes always deposit their eggs in water, and while the precise environment selected by each species is usually characteristic, the general statements made regarding different genera are often misleading. On the other hand, eggs and larvæ can be found and distinguished with ease. The eggs of *Culex* are deposited in an elongated boat-shaped mass (1, Fig. 3371) about the size and color of a caraway seed. These masses float on the surface until the embryos are hatched. *Anopheles'* eggs are deposited singly or in irregular detached groups, and each is provided with a floating organ (7, 8, 9, Fig. 3371) of air chambers to keep it at the surface. The eggs of *Stegomyia* (6, Fig. 3371) are also deposited singly and provided with a floating organ.

According to Carroll, Agramonte, and Lazear, they may be held dry for a month and yet develop when brought into water again.

The larvæ of all mosquitoes, familiarly known as "wrigglers," float at the surface for respiratory purposes,

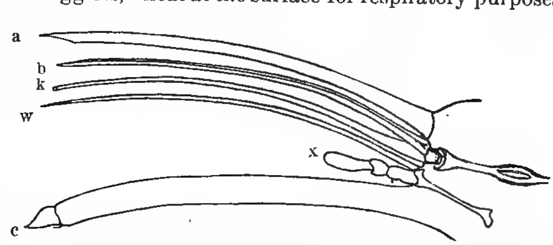

FIG. 3370.—Mouth Parts of Female Mosquito, diagrammatic. *a*, Labrum; *b*, mandible; *c*, labium; *k*, hypopharynx; *w*, maxilla; *x*, maxillary palp; *y*, basal joint of maxilla. (Paired organs represented by left member only.) (After Giles.)

and if they leave this position it is only for a short time. Those of *Culex* possess a very large head, a long respiratory siphon, and hang head downward at a considerable angle with the surface (Fig. 3372). *Stegomyia* larvæ assume nearly the same position, though somewhat more nearly transverse since the respiratory tube is shorter.

The position assumed by *Anopheles* larvæ, however, is strikingly horizontal (Fig. 3373) and close to the surface. These larvæ have a small head, no siphon, and the respiratory orifices are almost level with the back. The head, which is held barely below the surface, has been turned on the neck through a half-circle so that its lower aspect looks upward as it feeds on the floating débris. The pupæ (Fig. 3374, A and B) are also different for the different genera. In all, however, they float at the surface, taking no food but obtaining air through a curious auriculate respiratory siphon, until ready for the emergence of the perfect insect, which occurs through the back of the pupal thorax; the pupal skin floats at the surface as a rest for the adult before the latter starts on its initial flight. The process of breeding is retarded by colder weather, and the larvæ may even be frozen in masses of ice, and yet after thawing out regain their activity. Many, doubtless, regularly pass the winter in this way in higher latitudes.

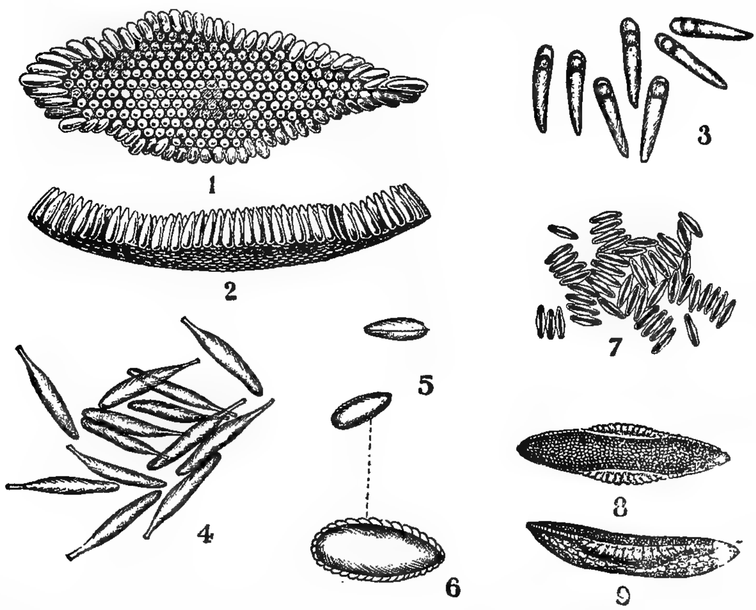

Fig. 3371.—Mosquito Eggs. 1, Egg mass of *Culex* seen from above; 2, same from the side (after Sambon); 3, separate *Culex* eggs; 4, eggs of *Panoplites* (after Daniels); 5, 6, eggs of *Stegomyia* (after Theobold); 7, group of *Anopheles* eggs floating; 8, 9, isolated eggs of *Anopheles maculipennis* to show floating organ. × 30. (After Nuttall.)

Diseases Transmitted by Mosquitoes.—There no longer exists a reasonable doubt that malarial disease is transmitted by the agency of mosquitoes. The painstaking elucidation of the life cycle of the hæmatozoa of malaria has demonstrated the existence of a sexual phase in the life history which takes place in the body of the mosquito and alternates with asexual generation found in human blood. (For further detail on the life history of this organism and its relation to the disease see article on *Plasmodium malariæ*). When Manson had a number of *Anopheles*, which had bitten a patient suffering from tertian ague in Italy, brought to England and there permitted them to bite two healthy students, who at a suitable time thereafter came down with malarial fever and showed the characteristic parasites of tertian ague in the blood, all objection to the possibility of this method of transmission of the disease was eliminated. Thus far no one has been able to find any other method of transference save by operative interference, and to judge from the life history of other parasites which manifest alternation of generations in different hosts no other method is at all probable, as Giles has so forcibly and logically demonstrated. It would, however, be hazardous to maintain that the asexual generation, even of the so-called human malarial parasites, may not be found also in other vertebrates. The immediate and abundant appearance of malaria among travellers in regions which have been depopulated or in which man is at best very rare, points indeed to the existence of another host for the asexual generation. On the other hand the sexual generation is known to inhabit only mosquitoes of the genus *Anopheles*, and experiments to infect various species of *Culex* and of other genera have thus far proved futile. All data thus far obtained show not only that, given *Anopheles*, the possibility of malaria exists, dependent to some extent no doubt upon other factors, but also that "no *Anopheles*, no malaria" is equally certain.

The relation of the mosquito to elephantiasis (*q. v.*) and filariasis (see *Nematoda*) has been equally definitely established. Here the mosquito draws the embryo worms, still surrounded by a delicate embryonic membrane, with the blood into its stomach. The embryos bore their way thence into the muscles and after a brief stay wander out into the labium. As in malaria and yellow fever, there is here also a stage of incubation, but unlike the former it is not a period of reproduction for the parasites but merely for the growth of the larvæ which are ready to be transferred to the human host when the mosquito has digested its first meal and is ready for the second. In this case certain species both of *Culex* and of *Anopheles* have been shown to afford proper environment for the development of the young worms.

The recent brilliant discoveries of the Yellow Fever Commission have demonstrated that the mosquito serves as the intermediate host for the parasite of yellow fever, and that this parasite is transmitted after an interval of approximately twelve days to non-immune individuals by a mosquito that has fed on the blood of a yellow-fever patient. It is the more striking that this mode of propagation has been definitely determined since the specific cause of the disease is as yet undiscovered. The mosquito responsible for the transmission of yellow fever is *Stegomyia fasciata*, although in all probability the culpability is shared by other species of the genus, if not by other genera.

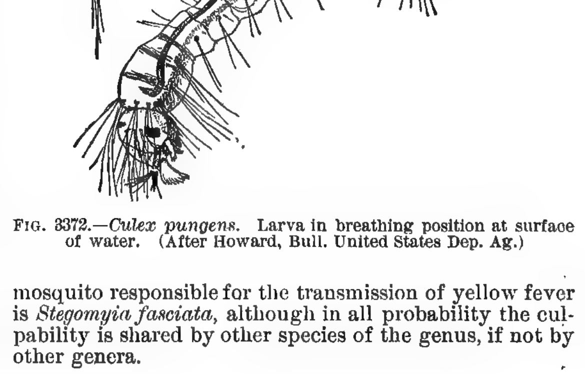

Fig. 3372.—*Culex pungens.* Larva in breathing position at surface of water. (After Howard, Bull. United States Dep. Ag.)

Recently Blanchard has summarized forcibly arguments to show that leprosy also is transmitted by mosquitoes. An ailment exclusively human, caused by a bacillus which grows only so far as known in human tissue and which cannot be transmitted by mere contact, the

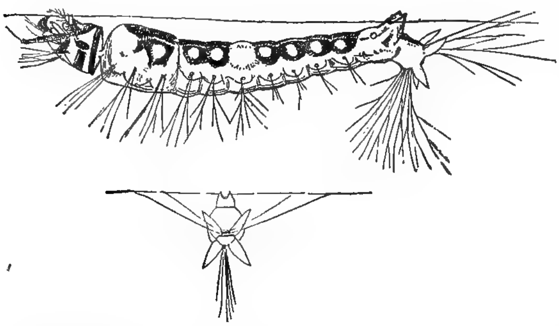

FIG. 3373.—*Anopheles maculipennis* Meig. Larva showing breathing position at surface of water. (After Howard, Bull. United States Dep. Ag.)

intervention of a biting insect appears indispensable that the bacilli may be brought into a favorable environment.

That the rôle is assumed by the mosquito rests only on conjectural and yet very probable grounds.

It has also been conjectured that tubercle bacilli are transmitted by mosquitoes, without positive evidence having been found for the view. While such unconfirmed suppositions must be regarded with suspicion, it is certain that in some instances bacteria are transmitted by mosquitoes. This is clearly shown by the observations of Giles on natives of India who had "applied for treatment on account of their faces being so swollen that they could scarcely open their eyes, and the fact that such cases are specially apt to occur among patients lying in a surgical ward makes it probable that the unusual effect of the bites in such cases is due to the mosquitoes having indulged in a previous feed from some wound secretion."

In this connection mention should be made of the annoyance caused by mosquitoes, of the irritation due to their bites, very noticeable in some persons, and of the limitation which these disturbances put upon the enjoyment and full utilization of the opportunities for invigorating outdoor existence which the warmer part of the year affords and the health of every individual demands. While trivial perhaps in the individual instance, it amounts in sum total to so much that for its remedy alone the severest measures against these pests should be advocated. When the loss of life and economic disturbance produced by yellow fever, and the still more serious but less striking since prolonged effects of malaria are taken into consideration, abundant reason exists for the immediate action of civilized communities to abate the mosquito nuisance. It must also be borne in mind that the casual introduction of a case of malaria, yellow fever, or elephantiasis into an otherwise healthy region gives conditions which may lead to the spread of the malady, if the place happens to be infested with the proper mosquito.

Dispersal of Mosquitoes.—The agency of mosquitoes in transmitting disease necessitates a consideration of the means which bring about the dispersal of the insects. In general, mosquitoes are home bred; and while this is true of *Culex* it is even more characteristic of *Anopheles*. Ross was able to find no case in which the distance from the infected house to the breeding-ground of this species was greater than one hundred and fifty yards. *Stegomyia* is said by Gorgas to be a very domestic mosquito, seldom leaving the immediate neighborhood of the place of its birth. The cause of a mosquito plague is then strictly local, although Smith thinks that swarms of the salt-water mosquito, *Culex solicitans*, may be carried twenty or even forty miles by a favorable wind. In most cases, however, it is clear that natural agents do not disperse them so widely. Howard has given numerous cases of their introduction into new regions by railway trains, and Grassi furnishes equally good evidence of their transportation by stage coaches.

Some observations have been made on the rôle of vessels in carrying mosquitoes from port to port. The insects probably are transported long distances in sheltered parts of the vessels and will breed in water barrels, and perhaps even in bilge water, during a voyage, thus furnishing a constant supply of adults. The emergence of mosquitoes from concealment on board ship would serve to explain the sudden outbreak of yellow fever at considerable intervals after leaving port. Ships coming into harbor have recorded swarms of mosquitoes carried out ten or even twenty miles by gentle off-shore winds. In this way vessels anchored at a considerable distance from infected ports, or even passing them without having had any direct communication, are subject to contamination with diseases transmitted by mosquitoes.

PROPHYLAXIS.—In view of the part played by the mosquito in the transmission of disease, it is fitting to inquire in the next place what means are available for the correction of the evil. A number of methods have been suggested which differ somewhat in applicability and efficacy, but all of which are valuable in certain cases. First may be mentioned the protection of individuals against the bite of the mosquito. This is accomplished by means of protecting the house with screens of mosquito netting or fine wire gauze in both doors and windows, or by screening beds with curtains of fine gauze, which completely shield the sleeper from the attack of the insect. In the case of persons engaged in outdoor employment it is necessary also to adopt some type of protection for the exposed parts of the body, such as wearing gloves on the hands and hoods or veils of netting over the face and neck.

The results of this practice are, that those in good health are not infected with the parasites carried by the mosquito, and on the other hand that sufferers from the disease do not give infection to the mosquitoes of the neighborhood. In the latter case it is imperative that such should not become sources of infection for the entire neighborhood, and the spread of the infection may be prevented by timely and perfect protection of the invalid from the attacks of mosquitoes. It is reasonable to require that all cases of malaria, as well as yellow fever and other infectious diseases, should be reported to

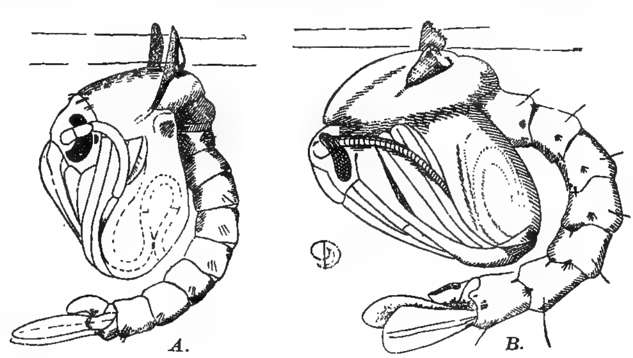

FIG. 3374.—Pupæ of *A*, *Culex pungens*. *B*, *Anopheles maculipennis*. (After Howard.)

the public health officer and that the isolation of the patient from mosquitoes be rigorously carried out, for otherwise the introduction of a single case may be the source of infection for an entire neighborhood. This has repeatedly been seen within recent times, as when, by the return of soldiers from the Spanish war, a previously unin-

fected neighborhood has been infected with a veritable epidemic of malaria.

This method has been successfully employed among the railroad operatives in Italy by Celli and Grassi with results so pronounced that the latter has proclaimed the possibility of freeing Italy entirely from malaria within a short time and making the most dreaded regions into health resorts. Under protection from mosquitoes, house epidemics of malaria ceased and convalescence was as easy at home as with change of air. Outside of the protected houses hardly a person escaped the disease; within them hardly any one was infected. Such mechanical prophylaxis is of the greatest advantage, particularly to those whose employment compels them to remain in a badly infected region. But it is after all a temporary measure and unattainable for a large part of the population of the world and under the conditions of tropical climates.

As protection against the bite of the mosquito, use has also been made of their repugnance to strong odors with meagre success. The essential oils of lavender, citronella, and eucalyptus are effective, when rubbed on the skin, in discouraging the attacks of mosquitoes; but the greatest success has been attained with the formula: castor oil, ℥ i.; alcohol, ℥ i.; oil of lavender, ʒ i. As a remedy for the irritating effects of the bites so noticeable on some persons, glycerin, alcohol, and indigo have been recommended, but in my experience tincture of iodine is best where the location of the bite does not inhibit its use, and is successful in the worst cases.

It has also been suggested by Koch that the generous and universal use of quinine would destroy the malarial organisms and thus do away with the disease. It may be doubted whether even under governmental support such a method could be sufficiently generally applied, in spite of the prejudices of a considerable part of the population, in temperate regions at least, even to approximate the end sought. The use of quinine will always be in favor among the educated part of the population of malarial regions and with travellers who are called upon to penetrate fever-ridden territory. Its sale at cost under government authority is a wise measure for the sanitary improvement of general health in the tropical colonies. In temperate regions many cases of malaria are not recognized as such; and it should be noted, moreover, that while affecting a most important element of the mosquito problem, the proposed method does not offer any solution for the other factors concerned.

The destruction of mosquitoes in the adult condition may be brought about by various means. In order to control yellow fever effectually this is essential as well as the protection of the sick against the bites of the mosquitoes. Most convenient of all is the burning of pyrethrum powder, although chlorine gas, formol vapor, chloral, and sulphur may be used with success also. The natural enemies of the adult mosquito are not rare, but it seems impracticable to hope to reduce noticeably the numbers of the insect by the multiplication of its enemies.

A more successful point of attack is offered by the immature larvæ and pupæ together with their breeding places. The large majority of the latter are not essential and many of them are indeed accidental collections of water, so that the most radical as well as the most effectual treatment of the subject is the abolition of such breeding places. To this end Ross has advocated the formation of mosquito brigades and the thorough examination and treatment of a region. This consists in the destruction of all unnecessary breeding spots and the regular treatment of necessary bodies of water so that they may not endanger general health by producing swarms of the insect. It is perfectly practicable in this manner to remove the sources of the infection and to reduce to the minimum limit the mosquitoes in any locality, since, as has already been mentioned, these insects are home bred and are rarely found at any considerable distance from their breeding places.

For a work of this character there are necessary: first, accurate knowledge regarding the location, number, and extent of the breeding places; second, capable treatment of the smaller localities that they may remain free of water even when it rains; and third, a scientific plan for handling the larger water areas that they may not serve for the production of mosquitoes. The smaller pools can usually be filled or drained by deepening the outlet without any considerable expense. The ease and effectiveness of such drainage work are entirely unappreciated, and the removal of a few small pools by draining or filling will often completely abate the mosquito nuisance in a given locality. Larger bodies of water require the cleaning away of marsh plants at the margin and the introduction of fish, such as the stickleback, sunfish, and goldfish, which are natural enemies of the larvæ. A most admirable example of the proper method for the treatment of the problem is given in the report on plans for the extermination of mosquitoes on the north shore of Long Island.

In many cases the most useful and successful method for the destruction of larval mosquitoes is the use of kerosene which has been advocated by Howard and has been successfully employed in many cases. The kerosene spreads over the surface and forms a film which smothers the larvæ and pupæ and catches the females as they come to deposit eggs. For the petrolization of a pool what is known as low-grade fuel oil which spreads rapidly and evaporates slowly is recommended and is best applied by pouring it on the surface of the water; spreading the oil through a spraying nozzle is less economical. Water treated with kerosene once a fortnight should be perfectly safe and the oil will not harm other animals than the aquatic insect larvæ.

The destruction of the mosquitoes and their breeding places has attracted much attention recently. The responsibility of the individual for the maintenance of his own property free from nuisance is thoroughly recognized and the breeding of mosquitoes will soon be included as a nuisance everywhere as it has been in several places, notably Havana, of which Ross speaks with admiration, commending "the straight-thinking Americans who quickly fine a person who breeds mosquitoes." That campaigns against mosquitoes are not only reasonable but eminently successful has been abundantly proved by work in many localities in the United States under the direction of Howard and others, by the work of Young in Hong-Kong, of the United States army in Cuba, and most striking of all by the campaign of Gorgas in Havana. Within ninety days after the adoption of regulations providing for the effectual isolation of the sick and for the destruction of all mosquitoes present in the infected and the neighboring houses Havana was freed from yellow fever; and in spite of repeated introduction of the disease from without, the death rate from yellow fever, which had averaged four hundred and sixty-two annually for ten years previous, was reduced to a total of five in 1901, and for malaria the reduction was from about three hundred and fifty in 1900 to only twenty-six for the first four months of 1902.

Results.—Finally it is proper to call to mind the effects which will be produced by the extermination of the mosquito. These evidently depend upon the character of the diseases. Yellow fever consists of a single illness followed by greater or less immunity from subsequent attacks; consequently the extermination of the mosquito will bring about the immediate disappearance of the disease. This has been the case in Havana. Elephantiasis and malaria, however, are protracted diseases. The parasites remain alive for years after the time of introduction by a mosquito. Elephantiasis is a permanent disease, and in malaria relapses occur long after the removal of the effecting agent; hence after the disappearance of all mosquitoes in a locality those persons who were previously infected will continue to suffer from these two diseases, so that not much change may be found within a period of several years. And yet a single year's work in mosquito extermination in Havana reduced the mortality

from malaria in that city ninety-three per cent. within eighteen months.

In consideration of the enormous losses which Celli sums up for a single country in the positive assertion that "malaria costs Italy annually thousands of lives and incalculable treasure," and in view of the even greater losses of other countries, it is not too much to hope that extended action may soon be taken through governmental agency for the correction of the evil by the eradication of the mosquito. *Henry B. Ward.*

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END OF VOLUME V.